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Arrang ment for supplying rock bolt

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ABSTRACT OF THE DISCLOSURE

A rock bolt feeding machine for feeding rock bolts to a bolting machine adapted to bolt rock bolts into a wall of a tunnel. The rock bolt feeding machine includes a vehicle, a storage unit located on the vehicle behind the bolting machine for storing a plurality of rock bolts, and a transfer mechanism provided on the vehicle for transferring the rock bolts to the bolting machine from the storage unit. A necessary number of rock bolts are taken out from the storage unit and successively supplied to the bolting machine by the transfer mechanism. By preparing a large amount of rock bolts in the storage unit beforehand, an operator can control a bolting operation from a remote and safe place. Since the operator does not have to set the rock bolts each time one bolting operation is complete, the excavation efficiency is improved and the excavation speed is raised.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A rock bolt feeding apparatus for feeding rock bolts to a bolting machine, comprising:

a vehicle;

a storage unit located on the vehicle behind a bolting machine for storing a plurality of rock bolts; and

transfer means provided on the vehicle for transferring the rock bolts to the bolting machine from the storage unit; and

2. The rock bolt feeding apparatus according to claim 1, wherein the transfer means includes at least one first movable member provided on the vehicle such that it can move forward and backward in a longitudinal direction of the vehicle, at least one second movable member provided on each first movable member such that it can move in a width direction of the vehicle, and at least one catching mechanism provided on each second movable member for catching the rock bolt.

3. The rock bolt feeding apparatus according to claim 2, wherein the at least one first movable member includes a plurality of first movable members spaced in the width direction of the vehicle, with each first movable member extending in the longitudinal direction of the vehicle, the plurality of first movable members are coupled to each other by a plurality of pairs of guide rods and screw rods extending transversely, and the second movable

13. A rock bolt storing apparatus comprising:

a storage unit for housing a plurality of rock bolts in a horizontally extending posture in a piled up manner, the storage unit including at least one storage column for piling up the rock bolts one after another, each storage column having an outlet at its bottom;

a plurality of pairs of hold pins, with each two pairs of hold pins being provided near the outlet of each storage column at opposite positions respectively such that one pair of hold pins in combination supports one end of a lowermost rock bolt among those piled up in each storage column and the other pair of hold pins support the other end of the lowermost rock bolt when the two pairs of hold pins are in a projecting position, and the two pairs of hold pins release the lowermost rock bolt when they are in a retracted position;

a plurality of pairs of guide brackets, with each two pairs of guide brackets being provided below each two pairs of hold pins such that each two pairs of guide brackets laterally contact the rock bolt that is released from the associated storage column as the associated pairs of hold pins are moved to the retracted position; and

at least one pair of support brackets, with each pair of support brackets being located between and below each two pairs of guide brackets for supporting a rock bolt from its bottom at longitudinal ends of the rock bolt when the rock bolt is laterally in contact with the associated pairs of guide brackets and the support brackets are in a support position, and being located below the guide brackets for not supporting the rock bolt and releasing it downward when the support brackets are in a release position.

14. The rock bolt storing apparatus according to claim 13, wherein a

23. A rock bolt feeding apparatus located in a tunnel for receiving a rock bolt in a horizontally extending posture, transferring it forward, and turning it into an upright posture inside the tunnel, comprising:

a base member movable forward and backward in a tunnel;

a pivotable member provided on the base member such that it can pivot about a main shaft extending horizontally in a direction perpendicular to a moving direction of the base member;

a clamp mechanism provided on the pivotable member for receiving a rock bolt from an upper opening thereof when it is in a receiving position, and for turning the rock bolt 90 degrees to a laid position while holding the rock bolt resiliently; and

an actuator for moving the clamp mechanism from the receiving position to the laid position.

24. The rock bolt feeding apparatus according to claim 23, wherein the clamp mechanism includes a first claw pivotable 90 degrees about a first shaft extending in the moving direction of the base member, at least one second claw each associated with the first claw and pivotable about a second shaft extending in parallel to the first shaft, a spring provided between the first and second claws for biasing the first and second claws oppositely in their pivotable directions respectively so as to clamp the rock bolt between the first and second claws, and a first stopper for restricting a pivot movement of each second claw when the clamp mechanism is in the receiving position, and for releasing the restriction on each second claw when the clamp mechanism is turned to the laid position, and the actuator includes a cylinder for causing the first claw to pivot about the first shaft.

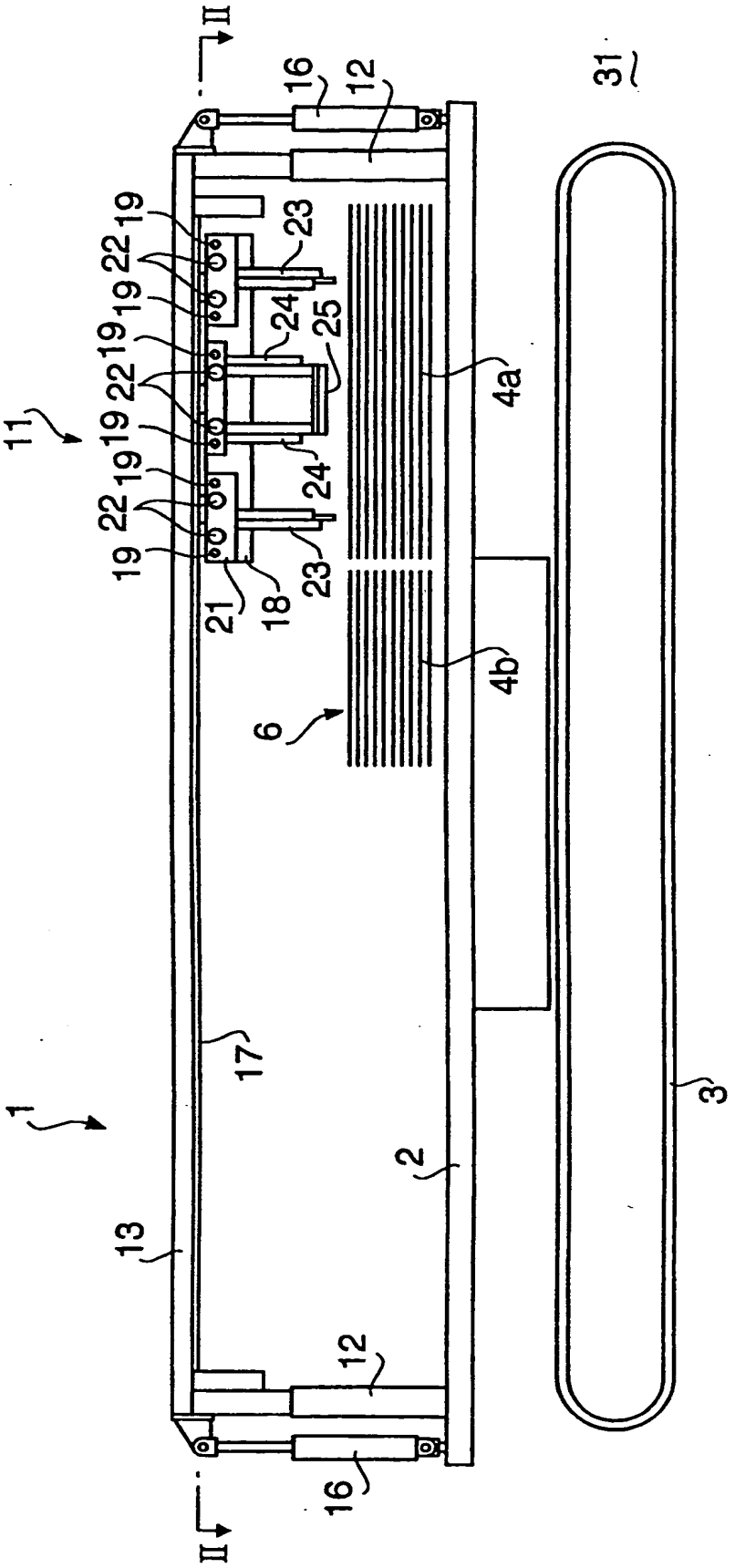
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FIG. 1

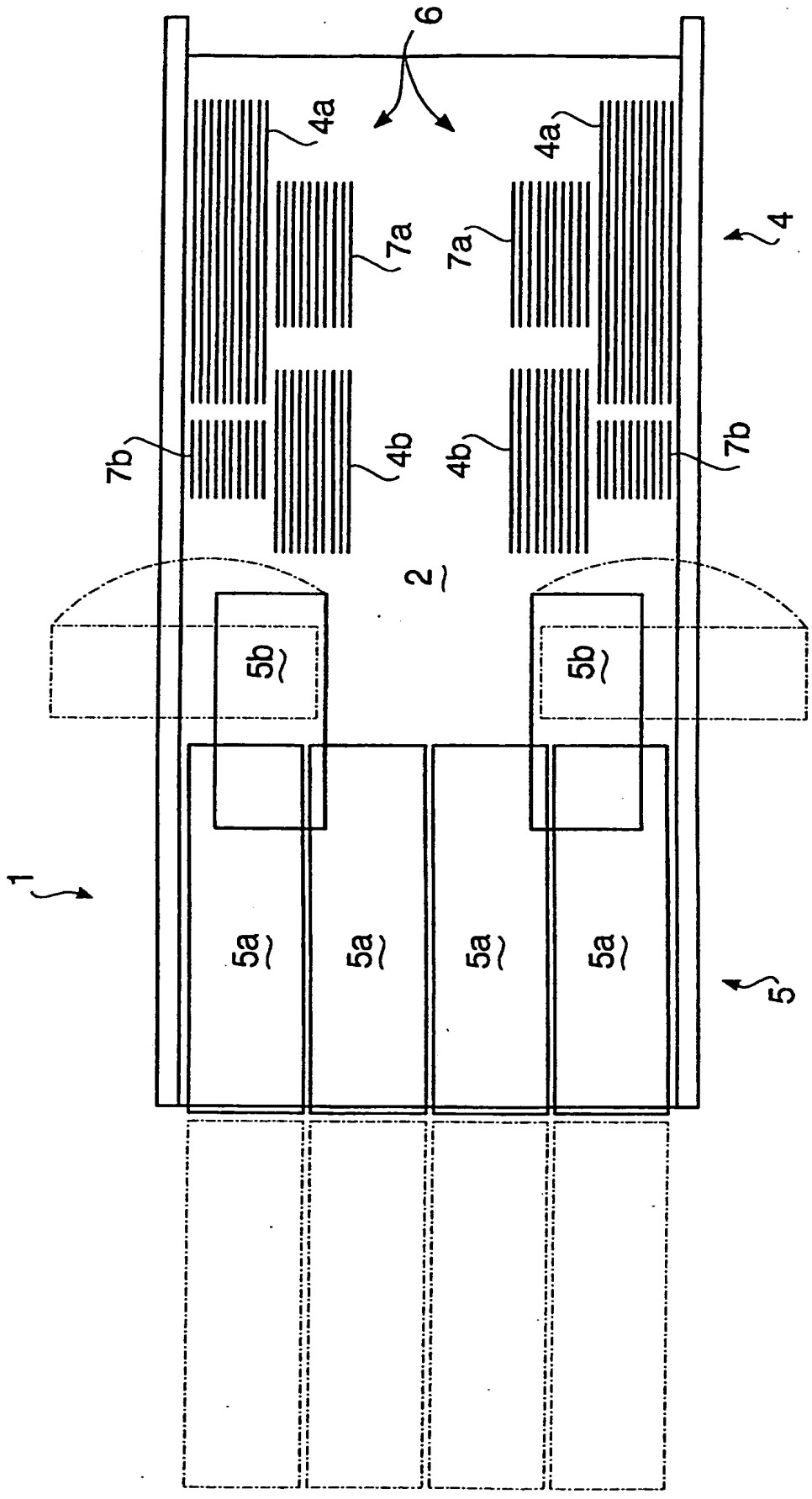

FIG. 5

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COMPLETE SPECIFICATION

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INVENTION TITLE:

Arrangement for supplying rock bolt

The following statement is a full description of this invention, including the best method of performing it known to me/us:–

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to an arrangement for storing rock bolts and supplying them to a bolting machine in a tunnel, and more particularly to such an arrangement that can automatically feed rock bolts at high speed.

Description of the Related Art

In a gate road of a coal mine or the like, rock bolts are bolted into a roof and ribs of a tunnel after excavation by a tunnel boring in order to prevent collapse of the tunnel. Conventionally, an operator takes out the rock bolts one by one by his hands from a rock bolt container and loads them into the bolting machine.

This rock bolt loading operation is inefficient since one rock bolt must be taken out from the container and set into the bolting machine each time the bolting process is finished. Accordingly, it is difficult to raise an excavation speed. In addition, when the coal mine is excavated, the operator is exposed to an undesired atmosphere including pulverized coal.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an apparatus for automatically feeding rock bolts into a bolting machine from a rock bolt container at high speed.

According to one aspect of the present invention, there is provided a rock bolt feeding apparatus for feeding rock bolts to a bolting machine adapted to bolt rock bolts into a wall of a tunnel, including a vehicle, a storage unit located on the vehicle behind the bolting machine for storing a plurality of rock bolts, and a transfer mechanism provided on the vehicle for transferring the rock bolts to the bolting machine from the storage unit. A necessary number of rock bolts are taken out from the storage unit and successively supplied to the bolting machine by the transfer mechanism. By preparing a large amount of rock bolts in the storage unit beforehand, an operator can control a bolting operation from a remote and safe place. Since the operator does not have to set the rock bolts each time one bolting operation is complete, the excavation efficiency is improved and the excavation speed is raised. Since the bolting machine and storage unit are arranged in the longitudinal direction of the vehicle in tandem, a cross sectional area of the tunnel need not be enlarged.

The transfer mechanism may include a plurality of first movable members provided on the vehicle such that they can move forward and backward in a longitudinal direction of the vehicle, a plurality of second movable members provided on the first movable members such that they can move in a width direction of the vehicle respectively, and a plurality of catching mechanisms provided on the second movable members for catching the rock bolts respectively. The storage unit may also store a plurality of

rod-shaped chemical anchors in addition to the rock bolts, and the transfer mechanism may also transfer the chemical anchors to the bolting machine. The chemical anchors may be bolted into the tunnel wall before the rock bolts are bolted.

According to a second aspect of the present invention, there is provided a rock bolt feeding apparatus for feeding rock bolts to a bolting machine, including a vehicle, a storage unit located on the vehicle behind a bolting machine for storing a plurality of rock bolts in a horizontally extending posture, a turn mechanism located on the vehicle between the storage unit and the bolting machine for holding the rock bolts in the horizontally extending posture, turning the rock bolts into an upright posture and supplying the upright rock bolts to the bolting machine, and a transfer mechanism located on the vehicle between the turn mechanism and the storage unit for taking out the rock bolts in the horizontally extending posture from the storage unit and delivering them to the turn mechanism.

A necessary number of rock bolts are taken out from the storage unit and successively transferred to the turn mechanism by the transfer mechanism, with the horizontal posture of each rock bolt being maintained. Each of the rock bolts is then turned to an upright posture and supplied to the bolting machine. By preparing a large number of rock bolts in the storage unit beforehand, an operator can control the bolting operation from a remote and safe place. It is also unnecessary for the operator to set the rock bolts each time the bolting operation is complete. Therefore, the excavation efficiency and speed are both raised.

The transfer mechanism may include a first movable member movable between the storage unit and the turn mechanism in a longitudinal direction of the vehicle, a second movable member provided on the first

movable member such that it can move in a width direction of the vehicle, a third movable member provided on the second movable member such that it can move in a height direction of the vehicle, and a catch mechanism provided on the third movable members for catching a rock bolt. The turn mechanism may include a base member movable in the longitudinal direction of the vehicle, a pivotable member provided on the base member, a clamp unit provided on the pivotable member for clamping a rock bolt, and an actuator for rotating the pivotable member relative to the base member.

According to a third aspect of the present invention, there is provided a rock bolt storing apparatus including a storage unit for housing a plurality of rock bolts in a horizontally extending posture in a piled up manner. The storage unit includes a plurality of storage columns, each for piling up the rock bolts one after another. The rock bolt storing apparatus also includes a plurality of pairs of hold pins. Each two pairs of hold pins are provided near opposite lower ends of each storage column such that each pair of hold pins in combination supports one end of a lowermost rock bolt among those piled up in each storage column when the each pair of hold pins are in a projecting position. Each two pairs of hold pins release the lowermost rock bolt when they are in a retracted position. The rock bolt storing apparatus further includes a plurality of pairs of guide brackets. Each pair of guide brackets are provided below each pair of hold pins such that they laterally contact the rock bolt that is released from the associated storage column upon moving of the associated pair of hold pins to the retracted position. The rock bolt storing apparatus also includes a plurality of support brackets. Each support bracket is located between and below each pair of guide brackets for supporting the released rock bolt from its bottom when the rock bolt is laterally in contact with the associated pair of guide brackets and the

support bracket is in a support position. Each support bracket is located below one of the guide brackets for not supporting the released rock bolt and allowing it to drop further when the support bracket is in a release position.

First, the hold pins are moved to the projecting position and the support brackets are moved to the support position. In this condition, the rock bolts stacked in each storage column are supported on the associated hold pins, with the lowermost rock bolt being in contact with the hold pins. When the hold pins are moved to the retracted position, the lowermost rock bolt in each storage column is no longer supported by the associated hold pins and therefore falls onto the associated support bracket. The remaining rock bolts subsequently drop inside each storage column by an amount equal to the downward movement of the lowermost rock bolt. Both sides of the lowermost rock bolt on the support bracket are supported by the associated guide brackets so that the vertical alignment of the lowermost rock bolt to the remaining rock bolts in each storage column is maintained. In this condition, the weight of all the rock bolts in each storage column is born by the associated support bracket. After that, the hold pins are returned to the projecting position such that all the rock bolts except for the lowermost one in each storage column are supported by the hold pins. The lowermost rock bolt is now only supported by the associated support bracket. Finally, the support bracket is moved to the release position thereby allowing the lowermost rock bolt to fall from each storage column. The rock bolts are eventually supplied to the bolting machine.

Preferably, the hold pins, guide brackets and support brackets are arranged such that a space for accommodating one rock bolt is formed by each pair of hold pins in the projecting position, an associated pair of guide brackets, and an associated support bracket in the support position. With

this structure, the downward movement of the lowermost rock bolt in each storage column upon retracting of the holding pins becomes substantially equal to a rock bolt diameter. Accordingly, it is ensured that only one rock bolt is released from each storage column upon moving of the associated support bracket to the release position.

A temporary storage unit and a carry off mechanism may further be provided below the storage columns. The temporary storage unit may receive all the rock bolts released from the storage columns except for one, and the carry off mechanism may unload the rock bolts one by one from the temporary storage unit. When the support brackets are simultaneously moved to the release position, the lowermost rock bolts are caused to drop from the respective storage columns. One of them is allowed to fall further and first supplied to the bolting machine. Other rock bolts are caught by the temporary storage unit, and unloaded in turn from the temporary storage unit by the carry off mechanism. Therefore, the rock bolts are supplied to the bolting machine one by one sequentially.

A transfer-and-turn mechanism may further be provided below the temporary storage unit for supplying the rock bolts to the bolting machine. The transfer-and-turn mechanism receives the rock bolts one at a time in a horizontally extending posture from the temporary storage unit, and transfers it a predetermined distance in a tunnel. Then, the transfer-and-turn mechanism turns the rock bolt to an upright posture from the laid posture and supplies it to the bolting machine.

According to a fourth aspect of the present invention, there is provided a rock bolt feeding apparatus including a base member movable forward and backward in a tunnel, a pivotable member provided on the base member such that it can pivot about a main shaft extending horizontally in a

direction perpendicular to a moving direction of the base member, a clamp mechanism provided on the pivotable member for receiving a rock bolt from an upper opening thereof when it is in a receiving position, and for turning the rock bolt 90 degrees to a laid position while holding the rock bolt resiliently, and an actuator for moving the clamp mechanism from the receiving position to the laid position. Use of a spring or the like may enable the clamp mechanism to resiliently hold the rock bolt.

First, the clamp mechanism is brought into the receiving position and receives a rock bolt from its upper opening. Next, the clamp mechanism is turned to the laid position by the actuator so that the rock bolt resiliently held in the clamp mechanism is turned 90 degrees transversely. Then, the base member is moved toward the bolting machine and the pivotable member is rotated about the main shaft so that the rock bolt takes an upright posture. The upright rock bolt is then supplied to the bolting machine. The opening of the clamp mechanism, which is directed upward when the clamp mechanism is in the receiving position, is now directed laterally. Therefore, the rock bolt can be taken in the width direction of the tunnel. Accordingly the entire system length need not be enlarged. Further, since the rock bolt is resiliently supported in the clamp mechanism, synchronous control such as releasing of hydraulic pressure is unnecessary.

The clamp mechanism may include a first claw pivotable 90 degrees about a first shaft extending in the moving direction of the base member, at least one second claw each associated with the first claw and pivotable about a second shaft extending in parallel to the first shaft, and a spring provided between the first and second claws for biasing the first and second claws oppositely in their pivotable directions respectively so as to clamp the rock bolt between the first and second claws. The clamp mechanism may further

include a first stopper for restricting a pivot movement of the second claw(s) when the clamp mechanism is in the receiving position, and for releasing the restriction on the second claw(s) when the clamp mechanism is turned to the laid position. The actuator may be a cylinder for causing the first claw to pivot about the first shaft.

Other objects, aspects and advantages of the present invention will become apparent to those skilled in the art to which the invention relates from the subsequent description of the embodiments and the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a side view of a rock bolt feeding apparatus according to one embodiment of the present invention;

Figure 2 illustrates a cross sectional view taken along the line II-II in Figure 1;

Figure 3 illustrates a front view of the rock bolt feeding apparatus shown in Figure 1;

Figure 4 schematically illustrates an enlarged view of a storage unit used in the apparatus shown in Figure 1;

Figure 5 illustrates a perspective plan view of the rock bolt feeding apparatus shown in Figure 1;

Figures 6 and 7 are similar to Figure 1 and illustrate another side views of the rock bolt feeding apparatus when rock bolts are carried forward from the storage unit respectively;

Figure 8 schematically illustrates a modification made to the apparatus shown in Figure 1;

Figure 9 illustrates a plan view of the apparatus shown in Figure 8;

Figure 10 illustrates a front view of the apparatus shown in Figure 8;

Figure 11 illustrates a side view of a rock bolt feeding apparatus according to a second embodiment of the present invention;

Figure 12 illustrates a plan view of the rock bolt feeding apparatus shown in Figure 11;

Figure 13 illustrates a rear view of the rock bolt feeding apparatus shown in Figure 11;

Figure 14 schematically illustrates an enlarged view of a storage unit used in the apparatus shown in Figure 11;

Figure 15 illustrates an enlarged view of a clamping device of a transfer mechanism employed in the apparatus shown in Figure 11;

Figure 16A illustrates a side view of a turn mechanism used in the apparatus shown in Figure 11;

Figure 16B illustrates a plan view of the turn mechanism;

Figure 16C illustrates a rear view of the turn mechanism;

Figure 17 also illustrates a side view of the turn mechanism when the turn mechanism is forwarded to the front end of a vehicle;

Figure 18 also illustrates a side view of the turn mechanism when the turn mechanism turns a rock bolt from a horizontally extending posture to an upright posture;

Figure 19 illustrates a transverse cross sectional view of a rock bolt housing apparatus having a plurality of storage columns according to a third embodiment of the present invention;

Figure 20 illustrates a longitudinal cross sectional view of the housing apparatus shown in Figure 19;

Figure 21 illustrates a cross sectional view as taken along the line XXI-XXI in Figure 20;

Figure 22 schematically illustrates a side view of the rock bolt housing apparatus placed on a vehicle, together with a rock bolt transfer-and-turn mechanism;

Figure 23A illustrates an enlarged side view of the rock bolt transfer-and-turn mechanism shown in Figure 22;

Figure 23B illustrates an enlarged plan view of the rock bolt transfer-and-turn mechanism;

Figure 23C illustrates an enlarged rear view of the rock bolt transfer-and-turn mechanism;

Figure 24 illustrates another side view of the transfer-and-turn mechanism when the mechanism is moved to the frond end of the vehicle;

Figure 25 also illustrates a side view of the transfer-and-turn mechanism when the mechanism turns a rock bolt from a horizontally extending posture to an upright posture;

Figure 26 illustrates a front view of a rock bolt feeding apparatus according to a fourth embodiment of the present invention;

Figures 27 to 29 are a series of front views of the rock bolt feeding apparatus illustrating a clamp mechanism of the apparatus turned to a laid position clockwise;

Figure 30 illustrates a plan view of a major portion of the rock bolt feeding apparatus shown in Figure 26;

Figure 31A illustrates a side view of the rock bolt feeding apparatus shown in Figure 26;

Figure 31B illustrates a plan view of the rock bolt feeding apparatus;

Figure 31C illustrates a rear view of the rock bolt feeding apparatus; and

Figure 32 also illustrates a side view of the rock bolt feeding apparatus located on a vehicle.

DETAILED DESCRIPTION OF THE INVENTION

Now, embodiments of the present invention will be described in reference to the accompanying drawings.

First Embodiment (Figures 1 to 10):

Referring to Figure 1, illustrated is a rock bolt feeding apparatus that is equipped with a vehicle 2 to be located in a tunnel 31 of a coal mine or the like. The vehicle 2 has a pair of crawlers 3, as best seen in Figure 3, so that it can move by itself in this embodiment. It should be noted that the vehicle 2 may be towed by another car situated in front of the vehicle 2. As illustrated in Figure 5, the vehicle 2 has a set of bolting machines 5 (5a, 5b) at its front portion to bolt rock bolts 4 (4a, 4b) into an inner wall of the tunnel 31. The rock bolting machine set 5 includes a plurality of roof bolting machines 5a for bolting the rock bolts 4a into the tunnel roof and a plurality of side wall bolting machines 5b for bolting the rock bolts 4b into the tunnel side walls.

The roof bolting machines 5a are arranged on the vehicle 2 such that they can move forward from the illustrated positions and project from the vehicle's front as indicated by the phantom lines. As indicated by the phantom lines in Figure 6, the roof bolting machines 5a are caused to project forward and turn 90 degrees about an axis perpendicular to the drawing sheet so that they take a standing position. As shown in Figure 5, the roof bolting machines 5a are arranged on the vehicle 2 in a longitudinal direction of the vehicle 2 when they receive the rock bolts 4a. The roof bolting machines 5a bolt the rock bolts 4a into the tunnel roof after they are turned to the standing posture as shown in Figure 6.

As illustrated in Figure 5, the side wall bolting machines 5b are arranged on the vehicle 2 in such a manner that they can rotate outward 90 degrees about their respective axes extending in a direction perpendicular to the drawing sheet as indicated by the phantom lines. The side wall bolting machines 5b receive the rock bolts 4b when they extend in the longitudinal direction of the vehicle 2, and turn 90 degrees in a horizontal plane to bolt the rock bolts 4b into the tunnel ribs.

The vehicle 2 also has a storage unit 6 for holding the rock bolts 4a and 4b on the vehicle 2 behind the rock bolting machines 5a and 5b. In the stock area 6, located are the relatively long rock bolts 4a and relatively short rock bolts 4b. The rock bolts 4a and 4b are contained in cassettes (Figure 4; will be described later). The storage unit 6 includes a plurality of cassettes. Each of the rock bolts has a nut portion (not shown).

As depicted in Figure 5, a plurality of relatively long rod-like chemical anchors 7a for use on the tunnel roof and a plurality of relatively short rod-shaped chemical anchors 7b for use on the tunnel ribs are also put in the stock area 6. These chemical anchors 7a and 7b are accommodated in cassettes like that shown in Figure 4. Each chemical anchor includes a sausage-like sack filled with anchorage (or sticking or adhesive agent/resin). The chemical anchors 7a and 7b are squeezed into bolt holes in the tunnel inner wall before the bolting machines 5a and 5b bolts the rock bolts 4a and 4b. As may be understood from the above, therefore, the bolting machines 5a and 5b first create the bolt holes in the tunnel roof and side walls, then force the chemical anchors 7a and 7b into the bolt holes, and bolt the rock bolts 4a and 4b.

Referring now to Figure 4, the chemical anchors 7a and 7b and the rock bolts 4a and 4b are arranged in the respective cassettes 8 (only one

cassette is illustrated). There are eight cassettes 8 on the vehicle 2 for accommodating the two groups of rock bolts 4a and 4b and the two groups of chemical anchors 7a and 7b, as understood from Figure 5. The rock bolts 4a and 4b and the chemical anchors 7a and 7b are placed on the vehicle 2 symmetrically as viewed from the top. Each cassette body 8 includes a plurality of vertical poles 9 spaced in the longitudinal direction as well as the width direction of the vehicle 2, and plate members 10 supported from the vertical poles 9 such that they can flap upward as indicated by the phantom lines.

Each plate member 10 holds one chemical anchor 7 (7a or 7b) or rock bolt 4 (4a or 4b) such that the chemical anchor/rock bolt extends in the longitudinal direction of the vehicle 2. The chemical anchors 7 and rock bolts 4 supported on the plate members 10 are clamped from the above by a feed apparatus (will be described) and lifted up in a particular order. When the support plate 10 no longer holds the rock bolt 4 or chemical anchor 7, it is flapped up by a lower rock bolt 4 or chemical anchor 7 when the lower rock bolt 4 or chemical anchor 7 on the lower support plate 10 is clamped and lifted by the feed apparatus. Therefore, the empty support plates 10 do not hinder other chemical anchor/rock bolt taking out operations.

As illustrated in Figures 1 to 3, the vehicle 2 is also provided with the feed apparatus 11 for transferring the rock bolts 4 and chemical anchors 7 from the stock area 6 to the bolting machines 5a and 5b. The feed apparatus 11 is supported from rail frames 13. The rail frames 13 have shrinkable vertical rods 12 together with cylinders 16, and extend above the vehicle 2 in the longitudinal direction of the vehicle 2. As best illustrated in Figure 2, there are three parallel rail frames 13 extending in the longitudinal direction of the vehicle 2. These rail frames 13 are spaced in

the vehicle width; one extends along the right edge, one extends along the center line and one extends along the left edge. The three rail frames 13 are connected to each other by cross beams 14 and 15, and raised and lowered simultaneously by four cylinders 16 at the corners. The cylinders 16 are shrunk or elongated according to the height of the tunnel 31. When the excavation is complete, the cylinders 16 are shrunk since the vehicle 2 needs a certain amount of clearance between the tunnel roof and itself in order to safely and smoothly back up toward a tunnel entrance.

Each rail frame 13 has one or two guide rails 17 extending along its lower surface as shown in Figure 1. The center rail frame 13 has two guide rails 17 and each of the lateral rail frames 13 has one guide rail 17 as shown in Figure 2. A first moving member 18 (18a, 18b, 18c, 18d) is engaged in each guide rail 17. The first moving members 18a and 18b on the right and center rail frames 13 are connected to each other by guide rods 19 and screw rods 20, and the first moving members 18c and 18d on the center and left rail frames 13 are likewise connected by another guide rods 19 and screw rods 20. Accordingly, the former two members 18a and 18b move together, and the latter two members 18c and 18d move together independently of the former ones. Each guide rod 19 is associated with one screw rod 20. Second moving members 21 (21a, 21b, 21c, 21d, 21e, 21f, 21g, 21h, 21i, 21j, 21k, and 21l) are skewered by the guide rods 19 respectively.

The second moving members 21 are caused to move in the width direction of the vehicle 2 along the associated guide rods 19 as the associated screw rods 20 are rotated by motors 22. Each second moving member 21 is independently traversed by the associated motor 22. As depicted in Figures 1 and 3, some of the second moving members 21 (21a, 21b, 21c, 21d, 21i, 21j, 21k, 21l) have arms 23 for catching the rock bolts 4a/4b. As understood

from Figures 6 and 7, each arm 23 is movable in the longitudinal direction of the vehicle 2 in order to cope with the long rock bolts 4a and short rock bolts 4b.

As shown in Figures 1, 6 and 7, other second moving members 21 (21e, 21f, 21g, 21h) have second arms 24 for catching the chemical anchors 7a/7b. Each of the second moving members 21 has a pair of arms 24, and a handle 25 spanning lower ends of the arms 24. The handle 25 has an arc surface that increases a contact area with the rod-shaped chemical anchor 7a/7b since the chemical anchor 7a/7b is a soft element due to its construction; it is made from the sausage-like bag filled with the adhesive agent as mentioned earlier. With an increased contact area, the handle 25 can pick up the chemical anchor 7a/7b without collapse.

The second arms 24 are shorter than the first arms 23. Therefore, the second arms 24 can move in the width direction of the vehicle 2 while they are holding the chemical anchors 7a/7b over the rock bolts 4a/4b supported from the first arms 23.

Now, an operation of the illustrated rock bolt feeding apparatus 1 will be described.

When an operator of the apparatus 1 wants to feed the rock bolts 4a and chemical anchors 7a to the roof bolting machines 5a, the bolting machines 5a are first placed on the vehicle 2 completely as shown in Figures 5 and 6. Then, as illustrated in Figures 1 to 3, the first moving members 18 are moved along the guide rails 17 until they are positioned above the long rock bolts 4a and long chemical anchors 7a.

Next, the second moving members 21 are independently moved along the guide rods 19 by the associated motors 22 such that the second moving members 21 for the rock bolts (21a, 21b, 21c, 21d, 21i, 21j, 21k, 21l) are

situated above the long rock bolts 4a and those for the chemical anchors (21e, 21f, 21g, 21h) are situated above the long chemical anchors 7a. As shown in Figure 5, the long chemical anchors 7a have been put next to the long rock bolts 4a with center points of the chemical anchors and rock bolts being aligned in the width direction of the vehicle. In correspondence with this arrangement, as best seen in Figure 2, the center second moving members 21e, 21f, 21g and 21h for the chemical anchors 7a are moved between the side second moving members 21a, 21b, 21c, 21d, 21i, 21j, 21k and 21l. In this manner, the center four moving members 21e to 21h are moved truly above the chemical anchors 7a, and the side moving members 21a to 21d and 21i to 21l are positioned above longitudinal ends of the rock bolts 4a respectively.

Subsequently, the arms 24 of the center moving members 21e to 21h are lowered by lift mechanisms (not shown) to catch center areas of the chemical anchors 7a, and the arms 23 of the side moving members 21a to 21d and 21i to 21l are lowered by lift mechanisms (not shown) to catch the rock bolts 4a near ends of the rock bolts. The arms 23 and 24 are then raised by the lift mechanisms so that the rock bolts 4a and chemical anchors 7a are taken out from the respective cassettes 8 (Figure 4).

As illustrated in Figure 6, the first moving members 18 are then carried forward along the guide rails 17 and the second moving members 21 are moved in the vehicle width direction in such a manner that the rock bolts 4a and chemical anchors 7a are respectively loaded into the roof bolting machine 5a. There are four bolting machines 5a along the front edge of the vehicle 2 as shown in Figure 5. Four rock bolts 4a and four chemical anchors 7a are simultaneously fed into these four bolting machines 5a by the moving members 21a to 21l (Figure 2). Accordingly, each roof bolting

machine 5a receives one rock bolt 4a and one chemical anchor 7a at a time.

When the rib bolting machines 5b receive the short rock bolts 4b and short chemical anchors 7b, these machines 5b are first situated completely on the vehicle 2. At this point, the roof bolting machines 5a are moved forward so that they do not interfere with the rib bolting machines 5b. Subsequent procedures to feed the rock bolts 4b and chemical anchors 7b into the rib bolting machines 5b are the same as described in connection with the roof bolting machines 5a. It should be noted that the distance between each pair of arms 23 for holding a single rock bolt 4b is shortened since the rock bolt 4b is shorter than the rock bolt 4a. Specifically, the two arms 23 of each pair are moved toward themselves in the vehicle longitudinal direction when the rock bolt feeding apparatus 1 finishes the rock bolt feeding to the roof bolting machines 5a. During this distance adjustment, the second moving members 21 are made stationary, and the associated arms 23 are only moved as understood from comparison of Figures 6 and 7. Thus, the arms 23 can catch the short rock bolts 4b appropriately. The distance between each pair of arms 24 is fixed since the arms are connected to each other by the associated handle 25. The spanning between the arms 24 is shorter than the short chemical anchor 7b as shown in Figure 7.

As described above, the necessary number of rock bolts 4 and chemical anchors 7 are taken out from the storage unit 6 and fed into the bolting machines 5 by the transfer machines 11. By preparing a sufficient or large amount of rock bolts 4 and chemical anchors 7 in the stock area 6, the operator can conduct the bolting operation from a remote and safe place manually or automatically. The bolting operation is sometimes performed in an atmosphere including pulverized coal, earth and sand. There is also a possibility of wall falling. The rock bolt feeding apparatus 1 of the present

embodiment dispenses with the operator's working in such an undesired environment.

With the illustrated apparatus, it is also unnecessary for the operator to set the rock bolts 4 and chemical anchors 7 to the bolting machines 5 each time the bolting operation is conducted. This raises an excavation efficiency and speed. When all the rock bolts 4 and chemical anchors 7 are picked up from the cassettes 8 on the vehicle 2, the empty cassettes 8 are replaced with new ones. Use of the cassettes 8 also contributes to improvement in the excavation efficiency.

Because the bolting machines 5 and stock area 6 are arranged in the longitudinal direction of the vehicle 2 in tandem, it is unnecessary to enlarge a cross section of the tunnel 31 when the apparatus 1 of the present embodiment is employed. If a time and work needed to carry the rock bolts 4 and chemical anchors 7 to the bolting machines 5 from the stock area 6 were primarily concerned, the stock area 6 would be provided close to the bolting machines 5. However, when the bolting machines 5 and stock area 6 were stacked in a height direction of the tunnel 31 or placed side by side in the width direction of the tunnel 31, then the height and/or width of the tunnel 31 would be enlarged. This is generally undesired. Therefore, the stock area 6 is provided immediately behind the bolting machines 5 in the present embodiment, and the tunnel cross section is not enlarged.

In this embodiment, the front cross beam 14 couples the front ends of the rail frames 17 as depicted in Figure 2. In order to avoid interference with the cross beam 14, the roof bolting machines 5a are caused to completely project from the vehicle 2 and turned 90 degrees as indicated by the phantom lines in Figures 5 and 6. Accordingly, the mechanisms for moving and turning the bolting machines 5a could have a complicated

structure. In view of this, a rather simple move-and-transfer mechanism is provided as illustrated in Figures 8 to 10.

In Figures 1 to 7 and 8 to 10, like elements are assigned like reference numerals and their description may be omitted in the following description.

The modified rock bolt feeding apparatus 1a has guide rails 26 on a vehicle 2, and a transfer mechanism 11 is placed on these rails 26. This apparatus 1a does not have a cross beam 14 (Figure 2) so that roof bolting machines 5a would not interfere with the cross beam 14 even if they were turned 90 degrees when they projected half from the vehicle 2 as depicted in Figure 8. Accordingly, the mechanism for moving the roof bolting machines 5a is simplified.

The guide rails 26 extend along the lateral edges of the vehicle 2 as best seen in Figure 9. First moving members 18 are supported on and guided by the guide rails 26 as best illustrated in Figure 10. The first moving members 18 support frames 27 via shrinkable/extendible vertical rods 12. As shown in Figure 8, cylinders 16 and linkages 28 also extend between the frames 27 and first moving members 18. The linkages 28 are removed when the cylinders 16 are shrunk.

As depicted in Figure 9, right and left upper frames 27 are connected to each other by a cross beam 29. Between these frames 27, guide rods 19 and screw rods 20 span. Second moving members 21 are provided on the guide rods 19 and screw rods 20. The second moving members 21 have first arms 23 for catching rock bolts and second arms 24 for catching chemical anchors.

Like to the rock bolt feeding apparatus 1 shown in Figures 1 to 7, the operator of the apparatus 1a is able to manipulate the bolting machines 5

from a remote and safe place manually or automatically. Further, the operator does not have to load the rock bolts 4 and chemical anchors 7 into the bolting machines 5 each time the bolting operation is finished. Consequently, the excavation efficiency and speed are raised. Because the bolting machines 5 and stock zone 6 are provided in tandem in the longitudinal direction of the vehicle 2, use of the apparatus 1a does not enlarge the cross sectional area of the tunnel 31.

Second Embodiment (Figures 11 to 18):

Referring to Figure 11, a rock bolt feeding apparatus 101 of this embodiment includes a vehicle 103 movable in a tunnel 102 such as gate road in a coal mine. The vehicle 103 has a pair of crawlers 104 and can move by itself. It should be noted, however, that the vehicle 103 may be pulled by a preceding vehicle. A roof bolting machine 106a is provided in front of the vehicle 103 such that it holds rock bolts 105a in a vertical posture and bolts the rock bolts into a roof of the tunnel 102. Between the roof bolting machine 106a and vehicle 103, provided is a transit mechanism 108 for receiving the rock bolts 105a from a turn machine 107 (will be described) and delivering them to the roof bolting machine 106a. The transit mechanism 108 includes a first turntable 110 that rotates about a first vertical axis 109 and a pair of second turntables 112 that rotate on the first turntable 110 about second vertical axes 111 respectively (Figure 12). Each second turntable 112 has three clamping portions 113 for holding the rock bolts 105a in a vertical posture. These three clamping portions 113 are evenly spaced (120-degree intervals) along the circumference of the associated table 112.

The vehicle 103 is also equipped with another rock bolting machines

106b for bolting rock bolts 105b into ribs of the tunnel 102. The rib bolting machines 106b first extend on the vehicle 103 in the longitudinal direction of the vehicle 103 as shown in Figure 12, and receive the rock bolts 105b. The rib bolting machines 106b are then turned 90 degrees outwards about their respective axes extending perpendicular to the drawing sheet as indicated by the phantom lines when the rib bolting machines bolt the rock bolts 105b into side walls of the tunnel 102.

Behind the rib bolting machines 106b and turn machines 107 on the vehicle 103, provided are storage units 114 for stocking with a number of rock bolts 105a and 105b. In the storage units 114, stored are long rock bolts 105a for the tunnel roof and short rock bolts 105b for the tunnel side walls. The rock bolts 105a and 105b extend in parallel to each other in the longitudinal direction of the vehicle 103. These rock bolts are housed in respective cassettes 115 as shown in Figure 14 (will be described), and therefore the storage units 114 are constituted by these cassettes 115. Each rock bolt 105a/105b has a nut portion (not shown).

Four cassettes 115 are provided on the vehicle 103 to house the two sets of long rock bolts 105a and the two sets of short rock bolts 105b respectively. Each cassette 115 includes a plurality of vertical poles 116 spaced in the width and length directions of the vehicle 103, and a plurality of horizontal plates 117 supported from the vertical poles 116. The plates 117 are retractable to an upstanding position as indicated by the phantom lines in Figure 14. Each plate 117 supports a single rock bolt 105a/105b such that the rock bolt extends in the longitudinal direction of the vehicle 103. The rock bolts 105a and 105b on the support plates 117 are picked up in a certain order by a rock bolt pick-up and transfer mechanism 118 (will be described).

The support plate 117 maintains its horizontal posture after the rock bolt 105a/105b is lifted up therefrom. However, when a lower rock bolt 105a/105b is caught and raised by the pick-up and transfer mechanism 118, the empty plate 117 thereabove is flapped upwards to the retracted position as indicated by the phantom lines. Accordingly, the empty plates 117 do not obstacle the rock bolt picking-up operations to be performed to the remaining rock bolts. The vertical rods 116 of each cassette 115 are spaced sufficiently to insure that the rock bolt catching and picking-up operation of the mechanism 118 is not hindered.

Between the stock areas 114 and transit machines 108 (bolting machines 106a), there are provided two turn mechanisms 107 for holding the long rock bolts 105a horizontally first and then turning them vertically as shown in Figures 11 and 12. The turn mechanisms 107 are located on the vehicle 103. As illustrated in Figures 11, 16A and 18, each turn station 107 has a base member 119 located on the vehicle 103 and movable in the longitudinal direction of the vehicle, a pivotable member 121 connected to the base member 119 and rotatable about a pin 120, clamp members 122 attached to the pivotable member 121 for holding the rock bolts 105a, and an actuator (cylinder) 123 for rotating the pivotable member 121 relative to the base member 119.

Specifically, there are provided a pair of rails 124 on the vehicle 103 for each turn machine 107 as shown in Figures 16A and 16C. The rails 124 extend in the longitudinal direction of the vehicle 103. A pair of grooved elements 125 attached to the lower face of the base member 119 engage the rails 124. The base member 119 has a bracket 126 for supporting the pivotable member 121 such that the bracket 126 can swing about the pin 120 as shown in Figure 16B. The pivotable member 121 is an elongated plate

member and secured to the pin 120. The pin 120 is secured to an arm 127 at one end. The other end of the arm 127 is coupled to a bracket 128 on the base member 119 via the cylinder 123.

If the base member 119 is forwarded on the rails 124 to front ends of the rails from the situation shown in Figure 16A, the turn machine 107 takes a position shown in Figure 17. After that, if the cylinder 123 is extended, the arm 127 and swingable member 121 rotate together about the pint 120 as shown in Figure 18. As a result, the swingable member 121 takes a vertical posture from the horizontal posture. The swingable member 121 has the clamp elements 122 via brackets 129. The rock bolt 105a is therefore held by the clampers 122 at two locations. Each clamper 122 is adjustable in the width direction of the vehicle 103 relative to the associated bracket 129 as guided by a guide 130.

Referring back to Figure 11, the vehicle 103 is further equipped with a pair of transfer mechanisms 118 for taking out the long rock bolts 105a from the stock areas 114 in the horizontal posture, and delivering them to the turn mechanisms 107 respectively. As shown in Figure 13, each transfer mechanism 118 generally extends in the width direction of the vehicle 103. Each transfer mechanism 118 is supported from a rail frame 132 over the vehicle 103. Each rail frame 132 is supported by a pair of pedestal frames 131 (Figure 12). The two rail frames 132 are spaced in the vehicle width direction, and extend in the vehicle longitudinal direction in parallel. These two rail frames 132 are connected to each other by front and rear transverse beams 133 as shown in Figure 12.

Each rail frame 132 has two guide rails 134 on its upper and outer side faces in the vehicle longitudinal direction to support first moving members 135 as best seen in Figure 13. The two moving members 135 on

each rail frame 132 are movable together between over the storage units 114 and over the turn machine 107 in the longitudinal direction of the vehicle 103 as best understood from Figure 12. Each first moving member 135 includes an L-shaped bracket 136 engaged on the guide rail 134, and a beam 137 outwardly extending from the L-shaped bracket 136 in the width direction of the vehicle 103. Each first moving member 135 can move above the front end of the vehicle 103 as indicated by the phantom line.

Each cross beam 137 has a guide rail 138 on its upper face (Figure 13). A second moving member 139 spans a pair of guide rails 138 in the longitudinal direction of the vehicle 103 in a manner such that it can move in the width direction of the vehicle 103 as best shown in Figure 12. The second moving member 139 includes an I-shaped bracket 140 spanning a pair of guide rails 138, and a vertical beam 141 extending downwards from the I-shaped guide bracket 140 (Figure 11).

As illustrated in Figure 11, each vertical beam 141 has a pair of guide rails 142 along its length. A third moving member 143 engages on these guide rails 142 such that it can move in the height direction of the vehicle 103. The third moving member 143 includes a main body 144 directly engaged on the rails 142, and a pair of extensions 145 extending downwards from the main body 144. Each extension 145 has a clamping device 146 (will be described) to clamp the rock bolts 105a.

By manipulating the first, second and third moving members 135, 139 and 143, it is possible to move a pair of clamping devices 146 to a desired position. The two clamping devices 146 then clamp a desired rock bolt 105a among those located in the storage units 114 and transfer it to the clampers 122 of the turn mechanism 107. As shown in Figure 13, each cross beam 137 extends beyond the vehicle 103 in the vehicle width direction so that all

the rock bolts 105a and 105b on the vehicle 103 can be picked up. Each vertical beam 141 has a length (height) sufficient to catch all the rock bolts 105a and 105b stacked on the vehicle 103.

The clamping device 146 attached to each extension 145 shown in Figure 13 is illustrated in Figure 15 in enlarged scale. The clamping device 146 includes a cylindrical main body 147 secured to the extension 145, and two pairs of handles 148 that are partly received in end openings of the main body 147 respectively. Each handle 148 has an elongated hole 149, which is slightly bent as a whole. Four pins 150 penetrate the clamping device main body 147 near its ends and the four elongated holes 149. Each handle 148 is operatively coupled to a link 152 by a pin 151. The other end of the link 152 is operatively coupled to a cylinder 153 by another pin 154. In the illustrated embodiment, each pair of handles 148 share a single cylinder 153.

When the cylinder 153 shrinks as shown in the left half of Figure 15, the handles 148 are opened. On the other hand, when the cylinder 153 extends as shown in the right half of Figure 15, the handles 148 are closed. If the clamping device 146 shown in Figure 15 is the left one in Figure 13, the left pair of handles 148 of the clamping device 146 of Figure 15 pick up the rock bolts 105a from the illustrated position toward the left in Figure 13, and the right pair of handles 148 of Figure 15 pick up the rock bolts 105b and 105a, if any, from the vehicle left edge toward the center. Only one pair of handles 148 of each clamp device 145 in Figure 15 are operated to clamp a part of a rock bolt. A pair of clamp devices 145 in combination clamp one rock bolt.

As shown in Figure 13, a conveyor belt 154 is provided between the pedestal frames 131 such that it can carry earth, sand and coal. The conveyor belt 154 extends in the longitudinal direction of the vehicle 103.

Now, the operation of the rock bolt feeding apparatus 101 will be described.

For the sake of simplicity and easier understanding, the following description only deals with one of the pick-up and transfer mechanisms 118.

When an operator wants to feed the rock bolts 105a to the roof bolting machine 106a, the first moving member 135 of the bolt feed machine 118 is first moved in the longitudinal direction of the vehicle 103 along the guide rail 134 until it is situated above the stock area 114. Then, the second moving member 139 is moved in the width direction of the vehicle 103 along the guide rails 138, and the third moving member 143 is moved in the height direction of the vehicle until a pair of clamping devices 146 face a desired long rock bolt 105a. Subsequently, the position of the clamping devices 146 is slightly adjusted to catch the rock bolt 105a.

After that, the third moving member 143 is lifted up, the second moving member 139 is traversed toward the vehicle center, and the first moving member 135 is forwarded. Then, the third moving member 143 is lowered and the second moving member 139 is moved horizontally to transfer the rock bolt 105a to the clampers 112 of the turn machine 107. The base member 119 of the turn machine 107 is advanced along the rails 124 until it reaches the front end of the vehicle 103 as illustrated in Figure 17. The cylinder 123 is extended to rotate the pivotable member 121 ninety degrees about the pin 120 so that the rock bolt 105a takes a vertically standing posture as shown in Figure 18.

The upright rock bolt 105a is then transferred to one of the clampers 113 of one of the second turntables 112 of the transit station 108 as shown in Figure 11. This process is repeated three times so that all the three clampers 113 of the second turntable 112 hold the rock bolts 105a

respectively. Then, the first turntable 110 is caused to rotate 180 degrees so that the second turntable 112 faces the roof bolting machine 106a. The three rock bolts 105a are subsequently supplied to the roof bolting machine 106a with their upstanding posture is being maintained.

Since there are two second turntables 112 on each first turntable 110, the other empty second turntable 112 is now positioned close to the front edge of the vehicle 103 and ready to receive another three rock bolts 105a. Then, the same process for picking up the rock bolts 105a from the stock area 114 and delivering them to the second turntable 112 is repeated. The first turntable 110 is rotated 180 degrees to feed the rock bolts 105a to the bolting machine 106a from this second turntable 112. In this manner, the desired number of rock bolts 105a are fed to the rock bolting machine 106a. Therefore, non-interrupted automatic rock bolt feeding is realized. After that, the roof bolting machine 106a bolts the long rock bolts 105a into the tunnel roof.

When the short rock bolts 105b are supplied to the rib rock bolting machine 106b, the first, second and third moving members 135, 139 and 143 of the transfer unit 118 are moved to catch a particular rock bolt 105b with the clamping devices 146. Then, the first to third moving members are moved to carry the rock bolt 105b to a nearby rib bolting machine 106b on the vehicle 103. This process may be repeated until a desired number of short rock bolts 105b are carried to the rib bolting machine 106b. After that, the rib bolting machine 106b is turned 90 degrees in a horizontal plane and starts the bolting operation toward the side wall of the tunnel 102.

The short rock bolts 105b are transferred from the stock area 114 to the side wall bolting machine 106b with their horizontal posture being maintained.

By preparing a large number of rock bolts 105a and 105b in the stock sections 114, the operator can control the bolting operation from a remote and safe place. The bolting operation may be automated. The bolting operation is generally performed in an undesired environment such as in a dusty atmosphere including pulverized earth, rock, sand and coal. There is also a possibility of roof falling in the tunnel. Use of the automatic rock bolt feeding apparatus of the invention protects the operator from such danger.

Further, since the operator does not have to set the rock bolt 105a/105b into the bolting machine 106a/106b each time the bolting operation is performed, the excavation efficiency is greatly improved and the excavation is speeded up. When the cassette 115 for the rock bolts 105a/105b becomes empty, it may be replaced with a new one filled with rock bolts. Use of such cassettes also contributes to the excavation efficiency improvement.

The long rock bolts 105a (or their cassettes 115) are put on the vehicle 103 such that they extend in the longitudinal direction of the vehicle so that their presence does not enlarge a cross section of the tunnel 102. The roof bolting machine 106a itself is a conventional machine. Since the rock bolts 105a are turned 90 degrees from the horizontal position to the vertical position by the turn machines 107 and fed to the bolting machine, a common bolting machine can be used.

Third Embodiment (Figures 19 to 25):

Figure 19 illustrates a rock bolt housing apparatus 201 including a plurality of rock bolt storage units 205 according to the present invention, and Figure 22 illustrates a vehicle 202 provided with the rock bolt housing apparatus 201.

As illustrated in Figure 22, the rock bolt housing apparatus 201 has a plurality of pedestals 203 and is located on the vehicle 202. The vehicle 202 runs inside a tunnel 299 of a coal mine, for example. The vehicle 202 has a pair of crawlers 204 and can move by itself in the illustrated embodiment. It should be noted, however, that the vehicle 202 may be towed by another vehicle. A roof bolting machine (not shown) for holding a rock bolt in a vertical posture and bolting it into a roof of the tunnel 299 is provided in front of the vehicle 202. A pair of rib bolting machines (not shown) for holding a rock bolt horizontally and bolting it into side walls of the tunnel 299 are also provided in front of or by the vehicle 202.

As illustrated in Figure 19, which is a transversal cross sectional view, the rock bolt housing apparatus 201 has the rock bolt storage units 205 (205a, 205b) arranged side by side. The rock bolt storage units 205 include a first group of units 205a for accommodating long rock bolts 206a to be bolted into the roof of the tunnel 299, and a second group of units 205b for accommodating short rock bolts 206b to be bolted into the side walls of the tunnel. In the drawing, approximate left one-third is occupied by the second group of storage units 205b and the remainder is occupied by the first group of storage units 205a. A partition wall 210 separates the first group of rock bolt storage units 205a from the second group of rock bolt storage units 205b. Fundamentally these rock bolt storage units 205a and 205b have a similar structure so that the first group of units 205a will be only described in the following passages.

Each of the rock bolt storage units 205a has a storage column 207a for receiving the rock bolts 206a in a stacked condition one after another, with each rock bolt being maintained in a generally horizontal posture. Each storage column 207a extends in a height direction of the vehicle 202,

and also extends in the longitudinal direction of the vehicle 202. The storage column 207a is defined by a pair of walls 208a spaced in the width direction of the vehicle 202. The gap between each adjacent vertical walls 208a is determined according to the diameter of the rock bolt 206a and the size of a nut 209a (Figure 20) received on the rock bolt 206a; it is designed to be slightly greater than them. The distance between two adjacent rock bolts 206a is equal to that between two adjacent walls 208a. A plurality of horizontally extending rock bolts 206a are piled up between each adjacent vertical walls 208a as mentioned earlier, but the rock bolts 206a are inclined to a certain extent as their position goes higher since the rock bolts 206a have the nuts 209a as shown in Figure 20.

The rock bolt storage units 205a are arranged side by side in the width direction of the vehicle 202. One of the two vertical walls 208a of one storage column 207a is therefore shared by a next storage column 207a. The rock bolt storage units 205a and 205b are placed in a housing 211 that is open at its top and bottom. The housing 211 has vertical walls 212 extending in the longitudinal direction of the vehicle 202, transverse walls 213 (Figure 20), and partition wall 210. The housing 211 stands on support frames 214 attached to the upper ends of the pedestals 203.

Each of the vertical walls 208a has a pair of hold pins 215a in its front and rear end faces near the bottom of the wall 208a (only one of the pins 215a is seen in Figure 19). As illustrated in Figure 20, these hold pins 215a can project into the housing 211 (or rock bolt storage column 207a). Therefore, two adjacent hold pins 215a of the neighboring vertical walls 208a can support one of the longitudinal ends of the lowermost one of the rock bolts 206a stacked in the storage column 207a when the hold pins are in the projecting position as best shown in Figure 19. When the hold pints 215a

are retracted, they are made apart from the lowermost rock bolt 206a. As shown in Figure 20, each hold pin 215a includes a smaller diameter stem 216a, a larger diameter stem 217a and a threaded portion 218a. The smaller diameter stem 216a extends in a hole 219a formed in the transverse wall 213 near its lower end, and projects into the rock bolt storage column 207a to contact the lowermost rock bolt 206a. The larger stem 217a is received in a guide block 220a attached to the outer surface of the transverse wall 213. The screw portion 218a extends through a coupling block 221a and is secured by a nut 222a. The coupling block 221a has a bracket 223a, and the bracket 223a is operatively coupled to a cylinder 225a via a linkage 224a. Therefore, the block 221a (or pin 215a) is pushed toward the transverse wall 213 or pulled in the opposite direction as the cylinder 225a is activated. Accordingly, when the cylinder 225a is shrunk, the bracket 223a is pulled outward and the pin 215a is retracted into the wall hole 219a. When the cylinder 225a is elongated, on the other hand, the bracket 223a is pushed inward and the pin 215a projects into the bolt storage column 207a. Since two pairs of hold pins 215a in combination support or release a single rock bolt 206a, the right and left cylinders 225a are driven synchronously.

Referring back to Figure 19, a guide bracket 226a is located truly below each vertical wall 208a, and extends in the longitudinal direction of the vehicle 202. Longitudinal ends of each guide bracket 226a serves as guide members for the hold pins 215a, and a substantial portion of the remainder of the guide bracket 226a is integrated to the associated vertical wall 208a. As illustrated, each two adjacent guide brackets 226a of the neighboring walls 208a contact a rock bolt 206a laterally that is allowed to drop upon retracting of the associated pins 215a. Below each guide bracket 226a except for the rightmost one, provided is a pair of support brackets 227a

(only one of the support brackets is seen in Figure 19). Each pair of support brackets 227a are moveable between a support position to support the bottom of the rock bolt 206a at longitudinal ends of the rock bolt as indicated by the phantom line and a release position to allow the rock bolt to drop further as indicated by the solid line. When the support brackets 227a are in the support position, the rock bolt 206a thereon contact the guide brackets 226a.

As illustrated in Figures 20 and 21, there are two groups of support brackets 227a arranged near the front and rear transverse walls 213 respectively. Each group of support brackets 227a are attached to a transverse member 228a at fixed intervals in the width direction of the vehicle 202. Thus, the support brackets 227a in each group move together. The two groups of support brackets 227a are moved synchronously since they in combination support the rock bolts 206a. Each transverse member 228a is received in a guide member 229a in such a manner that it can move horizontally within a certain range. Inside each guide member 229a, provided is a slippery material 230a such as resin plate in order to reduce a movement friction relative to the transverse member 228a. Each transverse member 228a is connected to a cylinder 232a via a bracket 231a such that it is moved horizontally upon actuation of the cylinder 232a. Each group of support brackets 227a are moved to the support position or release position as the associated cylinder 232a pushes or pulls the transverse member 228a.

In Figure 21, when the cylinders 232a for the long rock bolts 206a are shrunk (only one cylinder 232a is illustrated), the support brackets 227a are shifted to the release position from the support position. When two cylinders 232b for the short rock bolts 206b are elongated (only one cylinder

232b is shown), support brackets 227b are shifted to the release position from the support position.

As understood from Figure 19, if an arbitrary single storage column 207a is focused, a pair of support brackets 227a in the support position (only one is illustrated), two pairs of hold pins 215a (only one pair is illustrated) and two associated guide brackets 226a create a space to receive one rock bolt 206a. Specifically, when the rock bolt 206a is supported on the support brackets 227a, the two pairs of pins 215a are situated between the rock bolt 206a on the support brackets 227a and another rock bolt 206a on that rock bolt. In other words, the hold pins 215a can project into space formed between the first and second lowermost rock bolts 206a.

When the hold pins 215a project into the support position, the weight of all the rock bolts 206a piled up in the storage column 207a on the hold pins 215a is supported by the hold pins 215a, and the lowermost rock bolt 206a below the hold pins 215a and on the support brackets 227a bears no load. Therefore, when the support brackets 227a are moved to the release position, only the lowermost rock bolt 206a falls.

Below the support tongues 227a, provided are a pair of temporary storage units 233a for receiving all the rock bolts 206a falling from the rock bolt storage units 205a (or from the support tongues 227a) except one (only one temporary unit 233a is shown in Figure 19). The temporary storage units 233a are equipped with a pair of unloading devices 234a for carrying off the rock bolts 206a one by one (only one unloading device 234a is seen in Figure 19). Each of the temporary storage units 233a is primarily constituted by a stationary saw-like bracket 235a and a movable saw-like bracket 236a. Likewise, each of the unloading devices (carry off mechanisms) 234a is primarily constituted by the same stationary and

movable brackets 235a and 236a. Both the stationary and movable brackets 235a and 236a extend in the width direction of the vehicle generally along the transverse walls 213, but do not extend below the rightmost storage column 207a so that the rock bolt 206a falling from the rightmost rock bolt storage unit 205a is not received by the temporary storage units 233a. Each stationary bracket 235a has a plurality of flat portions 237a located below the walls 208a, and a plurality of right-angled triangle portions 238a below between the walls 208a alternately. Each movable bracket 236a is moved up and down by an associated cylinder 239a. Each movable bracket 236a has a plurality of right-angled triangle portions 240a positioned below the walls 208a, and flat portions 241a below between the walls 208a alternately. The right-angled triangles 238a and 240a of the stationary and movable brackets 235a and 236a are arranged in the same direction and have a similar configuration.

As illustrated in Figure 20, each stationary bracket 235a has a U-shaped cross section in its part, and is secured to the associated pedestal 203. The U-shaped cross section defines a groove, and the associated movable bracket 236a engages in this groove. As the cylinder 239a is activated, the movable bracket 236a is lifted up and down inside the groove.

The movable brackets 236a are first raised above the stationary brackets 235a by the cylinders 239a as shown in Figure 19. Then, a plurality of rock bolts 206a are released at the same time from the rock bolt storage units 205a. As a result, the rock bolt 206a falling from the rightmost storage column 207a does not hit the brackets 235a and 236a and descends naturally. Other rock bolts 206a from the remaining storage columns 207a are caught by the movable saw-like brackets 236a on the flat portions 241a.

After that, the movable saws 236a are lowered relative to the stationary saws 235a by the cylinders 239a such that the rock bolts 206a on the flat portions 241a of the movable saws 236a ride and slide on the triangle portions 238a of the stationary saws 235a. Eventually, the rock bolts 206a reach the flat portions 237a of the stationary saws 235a. As a consequence, the rock bolts 206a are moved toward the right (outwards in the vehicle width direction) by a distance equivalent to the one rock bolt. The rock bolt 206a supported on the rightmost flat portions 241a of the movable saws 236a is therefore caused to fall into a gap between the right edges of the saws 235a and the support frame 214 (or pedestal 203). A hopper 242a is attached to the pedestal 203 below this gap so that the falling rock bolt 206a is guided to a transfer-and-turn mechanism 243a by the hopper 242a.

The transfer-and-turn mechanism 243a receives the rock bolt 206a from the hopper 242a, carries it to the front end of the vehicle 202 as shown in Figure 22. The transfer-and-turn mechanism 243a then turns the rock bolt 206a into an upright position as indicated by the phantom line. As illustrated in Figures 23A, 23B and 23C, the transfer-and-turn mechanism 243a includes a base portion 244a provided on the vehicle 202 such that it can move in the longitudinal direction of the vehicle, a pivotable portion 246a swingably connected to the base portion 224a via a pin 245a, a pair of clampers 247a provided on the pivotable portion 246a for clamping the rock bolt 206a, and a cylinder 248a for causing the pivotable portion 246a to rotate ninety degrees relative to the base portion 244a.

Specifically, a pair of rails 249a are provided on the vehicle 202 in the longitudinal direction of the vehicle 202, and four engagement portions 250a of the base portion 244a engage on the rails 249a. The base portion 244a has brackets 251a for supporting the pivotable portion 246a when the

pivotable portion 246a rotates about the pin 245a. The pivotable portion 246a is an elongated plate and secured to the pin 245a. An arm 252a is fixedly coupled to the pin 245a at its one end. The other end of the arm 252a is coupled to a cylinder 248a. The cylinder 248a extends to a bracket 253a provided on the base portion 244a.

When the base plate 244a is advanced on the rails 249a from the situation shown in Figure 23A, the transfer-and-turn mechanism 243a takes the position shown in Figure 24. After that, the cylinder 248a is extended such that the arm 252a and pivotable portion 246a rotate about the pin 245a simultaneously as shown in Figure 25. Accordingly, the pivotable portion 246a takes an upright (vertical) posture from a laid down (horizontal) posture. The pivotable portion 246a has the clamping elements 247a for clamping the rock bolt 206a as shown in Figure 23B. As illustrated in Figure 23C, each of the clamping elements 247a includes a generally L-shaped bracket 254a mounted on the pivotable member 246a, a presser block 255a slidably placed on the L-shaped bracket 254a, and a cylinder 256a for moving the block 255a.

As the cylinder 256a shrinks, a space is created between the L-shaped bracket 254a and block 255a for accommodating the rock bolt 206a. The L-shaped brackets 254a are mounted on the pivotable member 246a such that the above-mentioned space faces the outlet of the hopper 242a (Figure 19). When the cylinder extends, the rock bolt 206a is sandwiched by the L-shaped bracket 254a and block 255a. When held in this manner, the rock bolt 206a does not fall from the clamping units 247a even if it is caused to stand vertically as shown in Figure 25. The transfer-and-turn mechanism 243a and rock bolt housing apparatus 201 constitute in combination a rock bolt feeding apparatus 270 (Figure 22). In Figure 19, a

conveyor 257 is provided between the two transfer-and-turn mechanisms 243a and 243b.

Now, an operation of the rock bolt feeding apparatus 270 will be described.

As illustrated in Figures 19 and 20, the hold pins 215a are first caused to project, and the holding brackets 227a are moved to the support position, and the rock bolts 206a are stacked in the storage columns 207a of the rock bolt storage units 205a of the rock bolt housing apparatus 201. In this situation, the lowermost one of the rock bolts 206a piled up in each storage column 207a is supported by the holding pins 215a so that no the rock bolts drop.

As the holding pins 215a are retracted, the lowermost rock bolts 206a are allowed to drop and caught by the support brackets 227a as shown in Figure 19. Accordingly, all the rock bolts 206a piled up in each of the storage columns 207a are shifted down by one rock bolt. For each of the rock bolt storage columns 207a, since the brackets 227a in the support position, holding pins 215a and guide brackets 226a are arranged in such a manner that a space for one rock bolt 206a is created between them, it is assured that all the stacked rock bolts 206 are moved downward by the amount of one rock bolt.

For each storage column 207a, the rock bolt 206a supported on the support brackets 227a is held by two pairs of guide brackets 226a in the width direction of the vehicle 202. Therefore, the vertical alignment of the rock bolts 206a in the storage column 207a is maintained. Accordingly, the lowermost rock bolt 206a supports the remaining rock bolts thereon. Subsequently, the hold pins 215a are caused to project again to support all the rock bolts 206a except the one supported on the support brackets 227a.

In this situation, the lowermost rock bolt 206a does not support any weight of the upper rock bolts. After that, the support brackets 227a are shifted to the release position, whereby the lowermost rock bolt 206 is caused to drop. This rock bolt dropping takes place simultaneously in other rock bolt storage columns 207a.

The falling rock bolts 206a are received on the temporary storage units 223a except for the rightmost one. The rightmost rock bolt 206a is guided to the clampers 247a of the transfer-and-turn mechanism 243a by the hopper 242a as shown in Figure 19. The transfer-and-turn mechanism 243a is caused to move forward along the rails 249a until it reaches the front end of the vehicle 202 as shown in Figures 22 and 24. The cylinder 248a is then extended so that, as shown in Figure 25, the pivotable member 246a rotates 90 degrees about the pin 245a to hold the rock bolt 206a in an upright posture. The upright rock bolt 206a is supplied to a bolting machine (not shown).

When this process is finished, the empty transfer-and-turn mechanism 243a is returned to the original position, and the next rock bolt 206a on the temporary storage unit 233a is released by the unloading mechanism 234a. Specifically, the movable saw-like members 236a are lowered relative to the stationary saw-like members 235a from the situation illustrated in Figure 19 by the cylinders 239a so as to push the next rock bolt 206a in the horizontal direction (to the right in the drawing) by the amount of one rock bolt, thereby allowing this rock bolt to fall from the temporary storage units 233a to the hopper 242a and in turn to the transfer-and-turn mechanism 243a. The rock bolt 206a is transferred to the bolting machine by the transfer-and-turn mechanism 243a in the same manner as described above. If another rock bolt 206a is needed by the bolting machine, the

movable saw-like members 236a are raised relative to the stationary saw-like members 235a by the cylinders 239a.

In this way, by lifting up and down the movable saw-like members 236a relative to the stationary saw-like members 235a, the rock bolts 206a on the flat portions 237a and 241a of these members 235a and 236a are carried to the right by the triangle portions 238a and 240a and released from the temporary storage units 233a one bolt at a time. In other words, the flat portions 237a and 241a constitute the temporary storage and the triangle portions 238a and 240a constitute the releasing mechanism.

When all the rock bolts 206a on the saw-like members 235a and 236a are caused to fall into the hopper 242a, the hold pins 215a and holding brackets 227a are activated to again allow the rock bolt storage units 205a (or storage columns 207a) to simultaneously release the rock bolts 206a. The rightmost rock bolt 206a drops directly into the hopper 242a and the remainder is received on the temporary storage units 233a as described above, and the same process as described is repeated to feed the rock bolts to the transfer-and-turn mechanism 243a one bolt at a time.

By preparing a large number of rock bolts 206a in the storage columns 207a beforehand, therefore, the operator can control the bolting operation from a remote and safe place. An atmosphere near the rock bolt storage area includes fine particle of coal, earth and sand. There is also a possibility of cave-in. Therefore, it is not desired for the operator to manually supply the rock bolts into the bolting machine in such a place. The rock bolt storage and feed apparatus of this embodiment will protect the operator from possible danger. Further, the rock bolts 206a are mechanically fed to the bolting machine one bolt at a time in sequence, the rock bolt feeding is automated and speeded up. This contributes to

improvement in excavation efficiency and speed.

A sensor may be attached to one of the cylinders 239a in order to count the number of extension/shrinkage of the cylinder 239a. When the sensor detects a fact that all the rock bolts 206a on the temporary storage units 233a are discharged, according to the count of the sensor, then the cylinders 225a and 232a may be activated automatically to control the hold pins 215a and support brackets 227a in such a manner that the lowest rock bolts 206a in the storage columns 207a are released simultaneously. Automation may easily be done in this manner. Alternatively, a sensor may be attached to one of the cylinders 225a or 232a for the support pins 215a or support brackets 227a in order to find out how many times the cylinder 225a or 232a is extended and retracted. When the sensor determines that all the rock bolts 206a in the storage columns 207a are released, according to the sensor output, then the cylinders 225a or 232a may be deactivated automatically, and a lamp or buzzer may be turned on to inform the operator that the rock bolt storage columns 207a are empty.

Instead of providing the sensors for detecting the extension/ retraction of the cylinders 225a, 232a and/or 239a, one or more other sensors may be provided for detecting presence/absence of the rock bolts 206a. However, the storage and feed apparatus 201 of this embodiment is utilized in an atmosphere including pulverized coal so that great care should be paid to explosion. In general, therefore, it is preferable not to employ such sensors that might spark from, for example, their contacts. Accordingly, the sensors for detecting the extension/retraction of the cylinders 225a, 232a and 239a, which are anti-explosive, are preferably used in this embodiment. It should be noted that the foregoing passages deals with the long rock bolts 206a, but the same story applies to the short rock bolts 206b.

Fourth Embodiment (Figures 26 to 32):

Now, a fourth embodiment according to the present invention will be described.

Referring first to Figure 32, illustrated is a vehicle 303 that can move back and forth with a pair of crawlers 302 in a tunnel 301 of a coal mine or the like. It should be noted that the vehicle 303 may be towed by another vehicle.

On the vehicle 303, provided is a rock bolt housing apparatus 305 having feet 306. Rock bolts 304 are automatically fed downwards in a horizontally extending posture from the rock bolt housing apparatus 305 one bolt at a time. A rock bolt feeding apparatus 307 is also provided on the vehicle 303 for receiving the rock bolts from the housing apparatus 305, transferring them forward, and turning them into a vertically extending posture from the horizontally extending posture. The rock bolts 304 in an upright posture are then fed to a bolting machine (not shown) from the feeding apparatus 307, and bolted into the tunnel roof from the bolting machine. The bolting machine is provided in front of the vehicle 303.

The rock bolt feeding apparatus 307 includes a base member 308 that is movable on the vehicle 303 in the longitudinal direction of the vehicle. A pair of rails 310 that extend in the longitudinal direction of the vehicle 303 are provided on the vehicle 303, and the base member 308 rides on these rails 310. As illustrated in Figures 31A to 31C, the base member 308 includes a main body 309 and engaging portions 331 engaged on the rails 310. The main body 309 is a generally rectangular plate.

A pivotable member 313 is provided on the base member 308 such that it can rotate about a main pin 312. The main pin 312 horizontally

extends in the width direction of the vehicle. Specifically, the main pin 312 is secured to the pivotable member 313, and the main pin 312 is rotatably (or journally) supported by a pair of brackets 314 mounted on the base member 308. One end of an actuation arm 315 is secured to a free end of the pin 312. The other end of the actuation arm 315 is operatively coupled to an end of a cylinder 317. The other end of the cylinder 317 is operatively coupled to a bracket secured to the base member 308.

The base member 308 is advanced on the rails 310 from the situation shown in Figure 31A to that shown in Figure 32, and the cylinder 317 is extended. Upon this cylinder extension, the actuation arm 315 and pivotable member 313 rotate 90 degrees about the pin 312 simultaneously as indicated by the phantom line in Figure 32. As a result, the pivotable member 313 stands up from a laid down posture. As shown in Figures 31A and 31B, two brackets 318 of L-shaped cross section are provided on the pivotable member 313 near front and rear ends respectively. Each bracket 318 has a clamping unit 319 for holding the rock bolt 304.

Two clamping units 319 are the same so that only one of them will be described below. The clamping unit 319 takes a receiving position for receiving the rock bolt 304 from the above as illustrated in Figure 26, and a 90-degree turned position as illustrated in Figure 29. The rock bolt 304 is clamped resiliently between these two positions. The clamping unit 319 is moved between the receiving position and turned position by a cylinder 320.

As shown in Figures 28 and 30, the clamping unit 319 includes a first claw 323 swingable 90 degrees about a first pin (first pivot center) 322. The first pin 322 is supported by a metallic element 321 attached to the L-shaped bracket 318. The first pin 322 extends in the longitudinal direction of the vehicle 303. The first claw 323 includes a support portion 324 for

supporting a lower portion of the rock bolt 304, a clamp portion 325 for clamping the rock bolt 304 laterally together with mating elements of second claws (only one second claw is illustrated), and a support portion 327 for supporting a pair of springs 326 (only one spring is seen).

A pair of second claws 329 are coupled to the first claw 323 by respective second pins (second pivot centers) 328 such that they can pivot about the second pins 328. The second pins 328 extend in parallel to the first pin 322. As shown in Figure 30, there are two second pins 329 on the right and left sides of the first claw 323. As shown in Figure 28, each second claw 329 includes a clamping face 330 for clamping the rock bolt 304 laterally in cooperation with the clamping face 325 of the first claw 323, and a support 331 for supporting the spring 326. Each second claw 329 has a generally "Z" shape when viewed laterally.

As shown in Figure 26, each spring 326 is supported between the extension 327 of the first claw 323 and the extension 331 of the second claw 329. Each spring 326 biases the second claw 329 relative to the first claw 323 such that it tends to pivot about the second pin 328 clockwise. In other words, the spring 326 forces the second claw 329 relative to the first claw 323 such that the rock bolt 304 is firmly clamped between the clamping faces 325 and 330 of the first and second claws. It should be noted that the spring 326 may be substituted for by an air spring or a cylinder filled with fluid such as oil.

The L-shaped bracket 318 is provided with a stop mechanism 322 for restricting a pivot movement of the second claw 329 when the support face 324 of the first claw 323 is horizontal as shown in Figure 26 and for releasing the restriction when the support face 324 of the first claw 323 is turned to vertical as shown in Figure 29. As illustrated in Figure 26, the stop

mechanism 332 includes a bolt 333 screwed into the L-shaped bracket 318 and a nut for adjusting and determining the screwed depth of the bolt 333. A head 335 of the bolt 333 abuts a bottom 336 of the second claw 329 and functions as a stop.

Specifically, in Figure 26, the second claw 329 tends to rotate clockwise with the biasing force of the spring 326, but the bolt head 335 contacts the bottom 336 of the second claw 329 and restricts the rotating movement of the second claw 329. As shown in Figures 27 and 28, however, the second claw bottom 336 leaves the bolt head 335 as the first claw 323 rotates. Eventually, as shown in Figure 29, the bolt head 335 is completely separated from the second claw bottom 336 and liberates the second claw 329. The bolt head 335 is rounded to smoothly contact the second claw bottom 336.

The L-shaped bracket 318 is also provided with another stopper 337 for insuring that the first claw 323 (specifically, the support surface 324 thereof) takes a horizontal posture when the first claw 323 is in the starting position as shown in Figure 26, and a third stopper 338 for insuring the vertical posture of the first claw 323 in the case of Figure 29. Between the first claw 323 and L-shaped bracket 318, provided is a horizontally extending cylinder 320 for causing the first claw 323 to pivot about the first pin 322. The cylinder 320 is pivotably coupled to a pair of brackets 340 of the pivotable member via a pin 339 at its one end. The other end of the cylinder 320 is coupled to the first claw 323 via a pin 341.

Now, an operation of the rock bolt feeding apparatus 307 will be described.

Referring to Figure 32, the base member 308 is first moved on the rails 310 to a position under the rock bolt housing apparatus 305. Then, as

shown in Figure 26, the cylinder 320 is shrunk to bring the clamping mechanism 319 into a stand-by condition for receiving a rock bolt. The rock bolt 304 discharged in the horizontal posture from the rock bolt housing apparatus 305 is caught between the first claw 323 and second claw 329. At that time, the gap between the mating faces 325 and 330 of the first and second claws 323 and 329 is set to be greater than the diameter of the rock bolt 304. In this manner, the rock bolt 304 is situated on the support surface 324 of the first claw 323.

After that, as shown in Figures 27 and 28, the cylinder 320 is elongated. As a result, the first claw 323 rotates clockwise about the first pin 322, and at the same time the second claw 329 rotates clockwise about the second pin 328. The rock bolt 304 is resiliently clamped between the clamping face 325 of the first claw 323 and the clamping face 330 of the second claw 329 by the biasing force of the spring 326. When the cylinder 320 extends almost its full stroke as shown in Figure 29, the rock bolt 304 reaches a 90-degree laid position while it is resiliently held with the spring force of the spring 326. Accordingly, the clamping mechanism 319 is switched to the clamping condition from the receiving condition of Figure 26.

Next, the base member 308 is forwarded on the rails to the front end of the vehicle 303 as shown in Figure 32. The cylinder 317 is then extended so as to rotate the pivotable member 313 ninety degrees relative to the base member 308 about the pin 312. Consequently, the rock bolt 304 stands up as indicated by the phantom lines in Figure 32. The upright rock bolt 304 is supplied to the bolting machine in front of the vehicle 303.

The upright rock bolt 304 can be taken out in the width direction of the vehicle 303. Therefore, no movement in the longitudinal direction of the vehicle 303 is required when the upright rock bolt 304 is taken out from the

clamping mechanism 319, and the entire system length does not become large. Further, because the rock bolt 304 is resiliently clamped by the spring 326, complicated synchronous control is not needed such as releasing of hydraulic pressure at the same time the rock bolt 304 is taken out.

After the rock bolt 304 is fed to the bolting machine, the cylinder 320 is shrunk thereby bringing the clamping mechanism 319 from the situation of Figure 29 to that of Figure 26. The base member 308 is then returned to the original position on the rails 310 under the rock bolt housing apparatus 305. Subsequently, another rock bolt 304 is supplied to the clamping mechanism 319 from the rock bolt storage apparatus 305, and the same process is repeated. It should be noted that the operation from Figures 26 to 29 and/or that from Figures 29 to 26 may be performed when the base member 308 is in a stationary condition or while it is moving forward/backward.

As described above, the rock bolt feeding apparatus 307 dispenses with complicated control and does not elongate the system entire length.

The above described and illustrated rock bolt feeding apparatuses and associated mechanism, machines, units, etc. are disclosed in Japanese Patent Application Nos. 11-268847, 11-268848, 11-268849, all filed on September 22, 1999, and 11-356127 filed on December 15, 1999 in JPO, the subject application claims priority of these Japanese Patent Applications, and the entire disclosures thereof are incorporated herein by reference.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A rock bolt feeding apparatus for feeding rock bolts to a bolting machine, comprising:

a vehicle;

a storage unit located on the vehicle behind a bolting machine for storing a plurality of rock bolts; and

transfer means provided on the vehicle for transferring the rock bolts to the bolting machine from the storage unit; and

2. The rock bolt feeding apparatus according to claim 1, wherein the transfer means includes at least one first movable member provided on the vehicle such that it can move forward and backward in a longitudinal direction of the vehicle, at least one second movable member provided on each first movable member such that it can move in a width direction of the vehicle, and at least one catching mechanism provided on each second movable member for catching the rock bolt.

3. The rock bolt feeding apparatus according to claim 2, wherein the at least one first movable member includes a plurality of first movable members spaced in the width direction of the vehicle, with each first movable member extending in the longitudinal direction of the vehicle, the plurality of first movable members are coupled to each other by a plurality of pairs of guide rods and screw rods extending transversely, and the second movable

7. A rock bolt feeding apparatus for feeding rock bolts to a bolting machine, comprising:

a storage unit located behind a bolting machine for storing a plurality of rock bolts in a horizontally extending posture;

a turn mechanism located between the storage unit and the bolting machine for holding the rock bolts in the horizontally extending posture, turning the rock bolts into an upright posture and supplying the upright rock bolts to the bolting machine; and

transfer means located between the turn mechanism and the storage unit for taking out the rock bolts in the horizontally extending posture from the storage unit and delivering them to the turn mechanism.

8. The rock bolt feeding apparatus according to claim 7, wherein the rock bolt feeding apparatus is provided on a vehicle, the transfer means includes at least one first movable member movable between the storage unit and the turn mechanism in a longitudinal direction of the vehicle, at least one second movable member provided on each first movable member such that it can move in a width direction of the vehicle, at least one third movable member provided on each second movable member such that it can move in a height direction of the vehicle, and at least one catch mechanism provided on each third movable member for catching a rock bolt.

9. The rock bolt feeding apparatus according to claim 8, wherein the at least one first movable member includes two first movable members spaced in the width direction of the vehicle.

10. The rock bolt feeding apparatus according to claim 8, wherein

each first movable member has a transverse beam extending in the width direction of the vehicle, and the associated second movable member is received on the transverse beam such that it can move in the width direction of the vehicle.

11. The rock bolt feeding apparatus according to claim 8, wherein each catch mechanism includes at least one main body extending in the width direction of the vehicle, and a pair of handles attached to ends of each main body for catching a rock bolt.

12. The rock bolt feeding apparatus according to claim 7, wherein the turn mechanism includes a base member movable in a longitudinal direction of a vehicle, a pivotable member provided on the base member, a clamp unit provided on the pivotable member for clamping a rock bolt, and an actuator for rotating the pivotable member relative to the base member.

13. A rock bolt storing apparatus comprising:

a storage unit for housing a plurality of rock bolts in a horizontally extending posture in a piled up manner, the storage unit including at least one storage column for piling up the rock bolts one after another, each storage column having an outlet at its bottom;

a plurality of pairs of hold pins, with each two pairs of hold pins being provided near the outlet of each storage column at opposite positions respectively such that one pair of hold pins in combination supports one end of a lowermost rock bolt among those piled up in each storage column and the other pair of hold pins support the other end of the lowermost rock bolt when the two pairs of hold pins are in a projecting position, and the two pairs of hold pins release the lowermost rock bolt when they are in a retracted position;

a plurality of pairs of guide brackets, with each two pairs of guide brackets being provided below each two pairs of hold pins such that each two pairs of guide brackets laterally contact the rock bolt that is released from the associated storage column as the associated pairs of hold pins are moved to the retracted position; and

at least one pair of support brackets, with each pair of support brackets being located between and below each two pairs of guide brackets for supporting a rock bolt from its bottom at longitudinal ends of the rock bolt when the rock bolt is laterally in contact with the associated pairs of guide brackets and the support brackets are in a support position, and being located below the guide brackets for not supporting the rock bolt and releasing it downward when the support brackets are in a release position.

14. The rock bolt storing apparatus according to claim 13, wherein a

space for accommodating one rock bolt is defined by each two pairs of hold pins in the projecting position, associated two pairs of guide brackets, and associated pairs of support brackets in the support position.

15. The rock bolt storing apparatus according to claim 13 further including a temporary storage unit and a carry off mechanism, and wherein the storage unit includes a plurality of storage columns arranged next to each other, each storage column being adapted to store a plurality of rock bolts one after another piled up in a height direction of the storage column, the temporary storage unit is located below the storage unit to receive all the rock bolts released from the outlets of the plurality of storage columns except for one, and the carry off mechanism unloads the rock bolts one by one from the temporary storage unit.

16. The rock bolt storing apparatus according to claim 15, wherein the carry off mechanism includes a stationary saw-like bracket, a movable saw-like bracket, and a cylinder for lifting up and down the movable saw-like bracket relative to the stationary saw-like bracket.

17. The rock bolt storing apparatus according to claim 14 further including a temporary storage unit and a carry off mechanism, and wherein the storage unit includes a plurality of storage columns arranged next to each other, each storage column being adapted to store a plurality of rock bolts one after another piled up in a height direction of the storage column, the temporary storage unit is located below the storage unit to receive all the rock bolts released from the outlets of the plurality of storage columns except for one, and the carry off mechanism carries the rock bolts one by one off the

temporary storage unit.

18. The rock bolt storing apparatus according to claim 17, wherein the carry off mechanism includes a stationary saw-like bracket, a movable saw-like bracket, and a cylinder for lifting up and down the movable saw-like bracket relative to the stationary saw-like bracket.

19. The rock bolt storing apparatus according to claim 15 further including a transfer-and-turn mechanism for receiving the rock bolts unloaded from the temporary storage unit one at a time, transferring each rock bolt in a horizontally extending posture a predetermined distance, and turning it into an upright posture.

20. The rock bolt storing apparatus according to claim 16 further including a transfer-and-turn mechanism for receiving the rock bolts unloaded from the temporary storage unit one at a time, transferring each rock bolt in a horizontally extending posture a predetermined distance, and turning it into an upright posture.

21. The rock bolt storing apparatus according to claim 17 further including a transfer-and-turn mechanism for receiving the rock bolts unloaded from the temporary storage unit one at a time, transferring each rock bolt in a horizontally extending posture a predetermined distance, and turning it into an upright posture.

22. The rock bolt storing apparatus according to claim 18 further including a transfer-and-turn mechanism for receiving the rock bolts

unloaded from the temporary storage unit one at a time, transferring each rock bolt in a horizontally extending posture a predetermined distance, and turning it into an upright posture.

23. A rock bolt feeding apparatus located in a tunnel for receiving a rock bolt in a horizontally extending posture, transferring it forward, and turning it into an upright posture inside the tunnel, comprising:

a base member movable forward and backward in a tunnel;

a pivotable member provided on the base member such that it can pivot about a main shaft extending horizontally in a direction perpendicular to a moving direction of the base member;

a clamp mechanism provided on the pivotable member for receiving a rock bolt from an upper opening thereof when it is in a receiving position, and for turning the rock bolt 90 degrees to a laid position while holding the rock bolt resiliently; and

an actuator for moving the clamp mechanism from the receiving position to the laid position.

24. The rock bolt feeding apparatus according to claim 23, wherein the clamp mechanism includes a first claw pivotable 90 degrees about a first shaft extending in the moving direction of the base member, at least one second claw each associated with the first claw and pivotable about a second shaft extending in parallel to the first shaft, a spring provided between the first and second claws for biasing the first and second claws oppositely in their pivotable directions respectively so as to clamp the rock bolt between the first and second claws, and a first stopper for restricting a pivot movement of each second claw when the clamp mechanism is in the receiving position, and for releasing the restriction on each second claw when the clamp mechanism is turned to the laid position, and the actuator includes a cylinder for causing the first claw to pivot about the first shaft.

25. The rock bolt feeding apparatus according to claim 24 further including a second stopper in contact with the first claw for causing the first claw to take a horizontal posture when the clamp mechanism is in the receiving position, and a third stopper in contact with the first claw for causing the first claw to take a vertical posture when the clamp mechanism is in the laid position.

26. The rock bolt feeding apparatus according to claim 24, wherein the at least one second claw includes two second claws located on both sides of the first claw.

27. Rock bolt feeding apparatus substantially as hereinbefore described with reference to the drawings and/or Examples.

28. Rock bolt storage apparatus substantially as hereinbefore described with reference to the drawings and/or Examples.

29. The steps, features, compositions and compounds disclosed herein or referred to or indicated in the specification and/or claims of this application, individually or collectively, and any and all combinations of any two or more of said steps or features.

DATED this TWENTY FIRST day of SEPTEMBER 2000

Ishikawajima-Harima Heavy Industries Co., Ltd.

by DAVIES COLLISON CAVE
Patent Attorneys for the applicant(s)

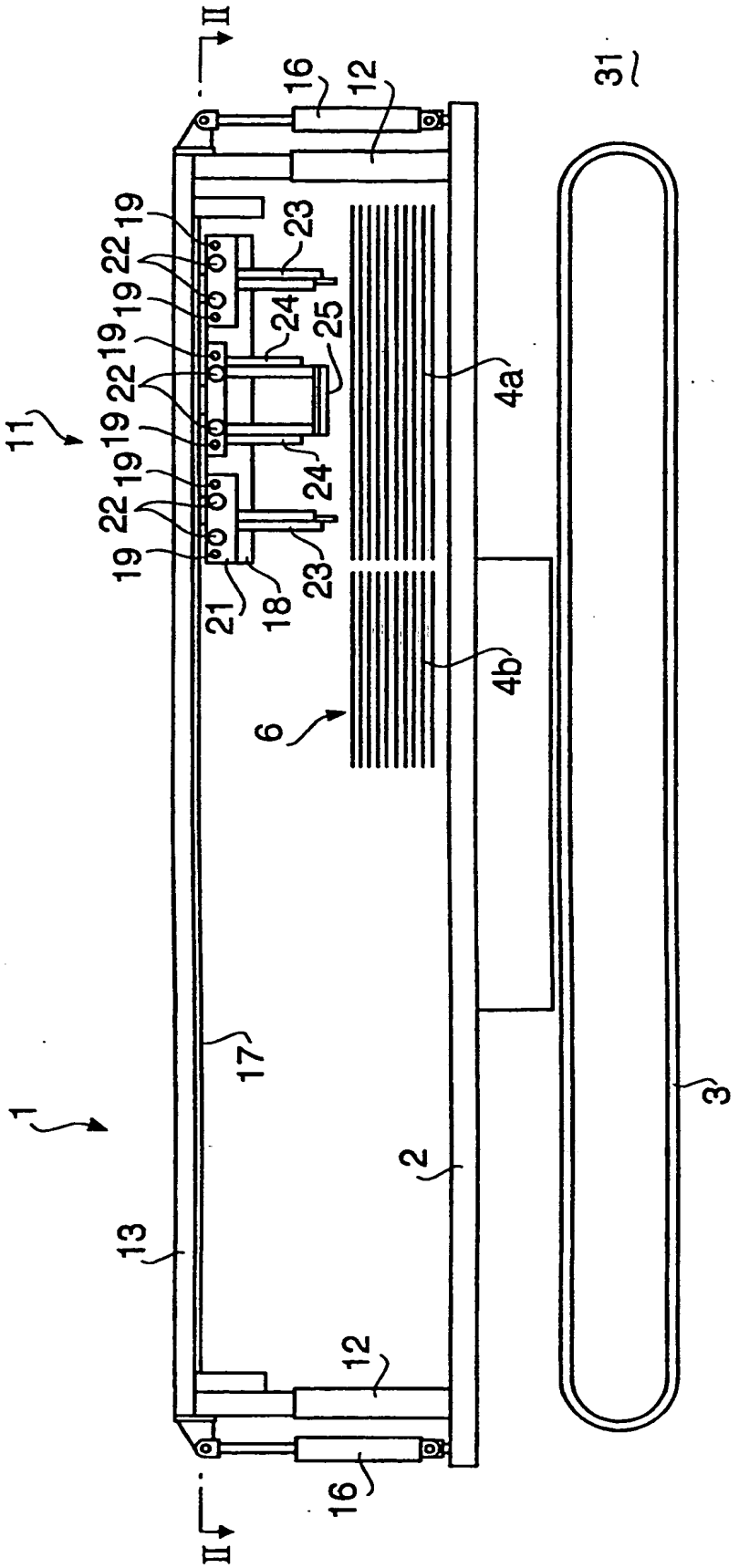
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FIG. 1

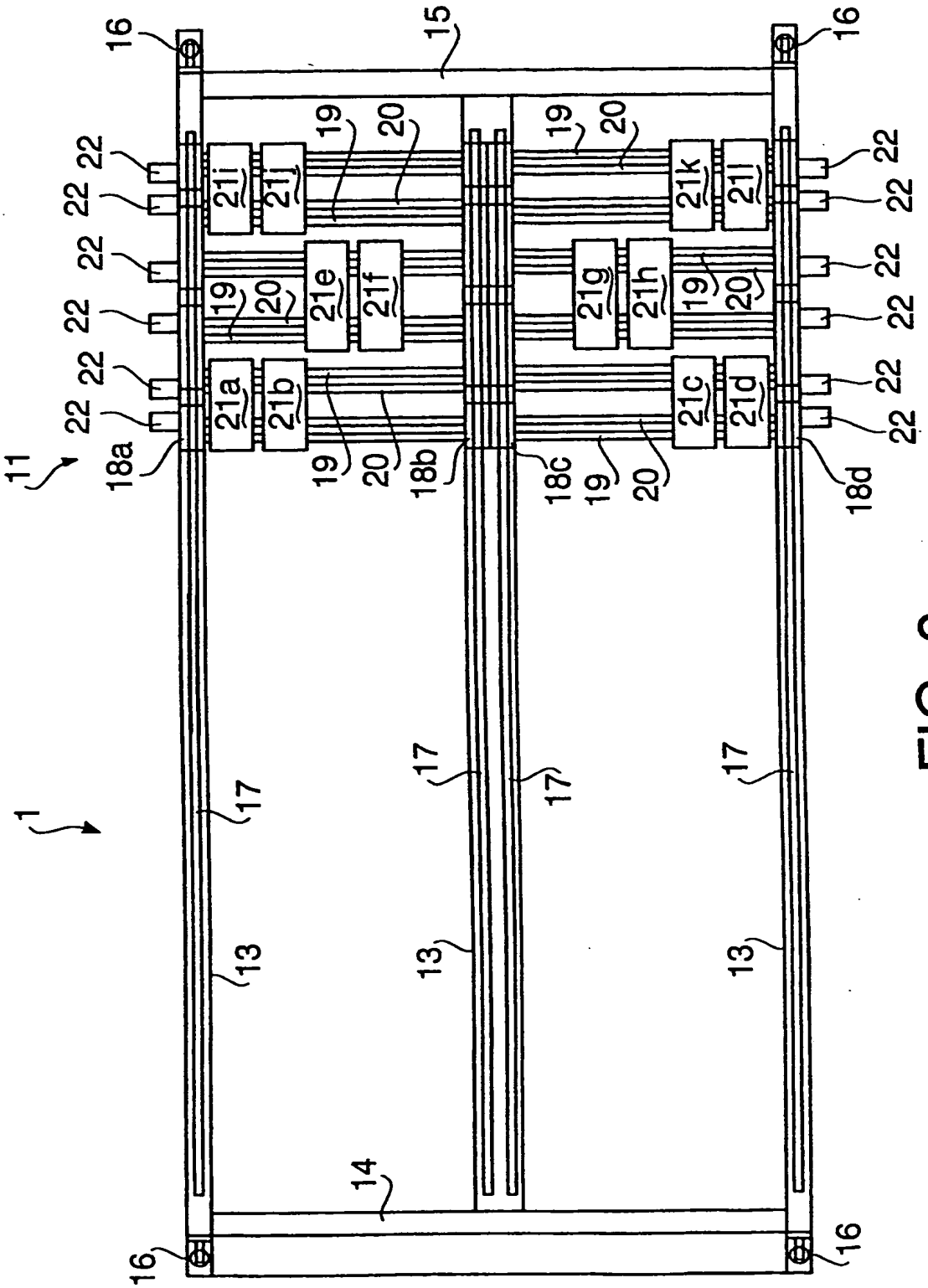
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FIG. 2

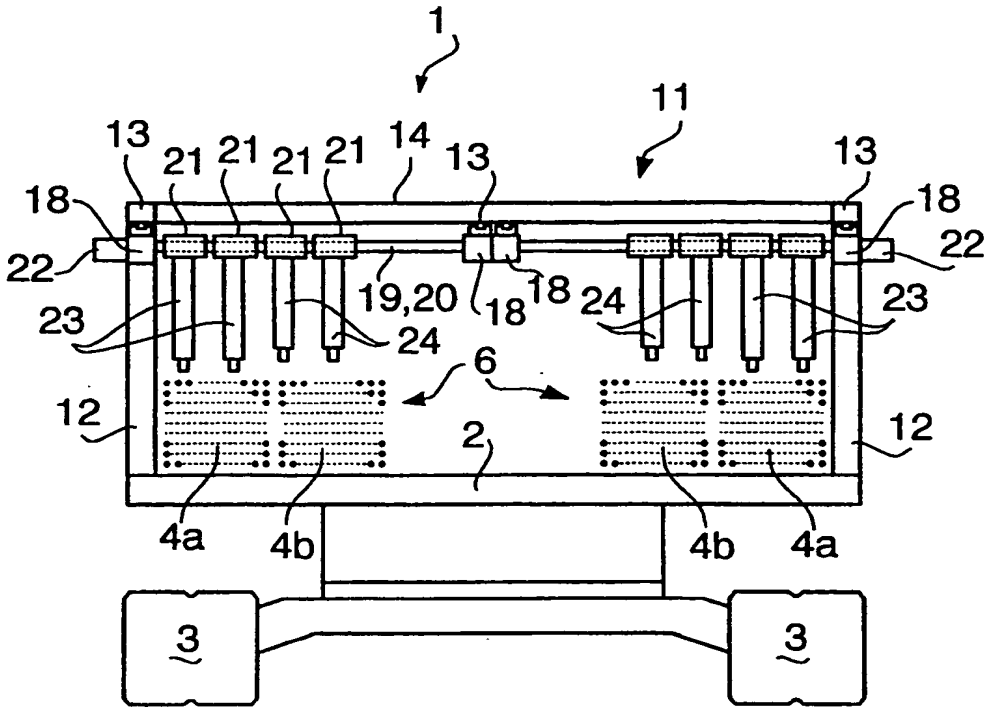
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FIG. 3

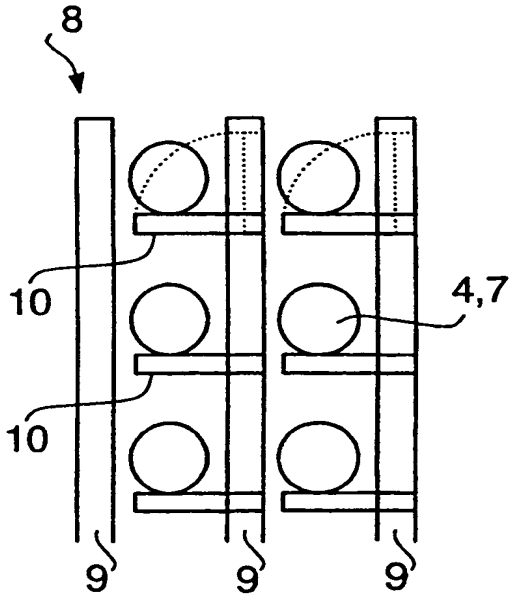
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FIG. 4

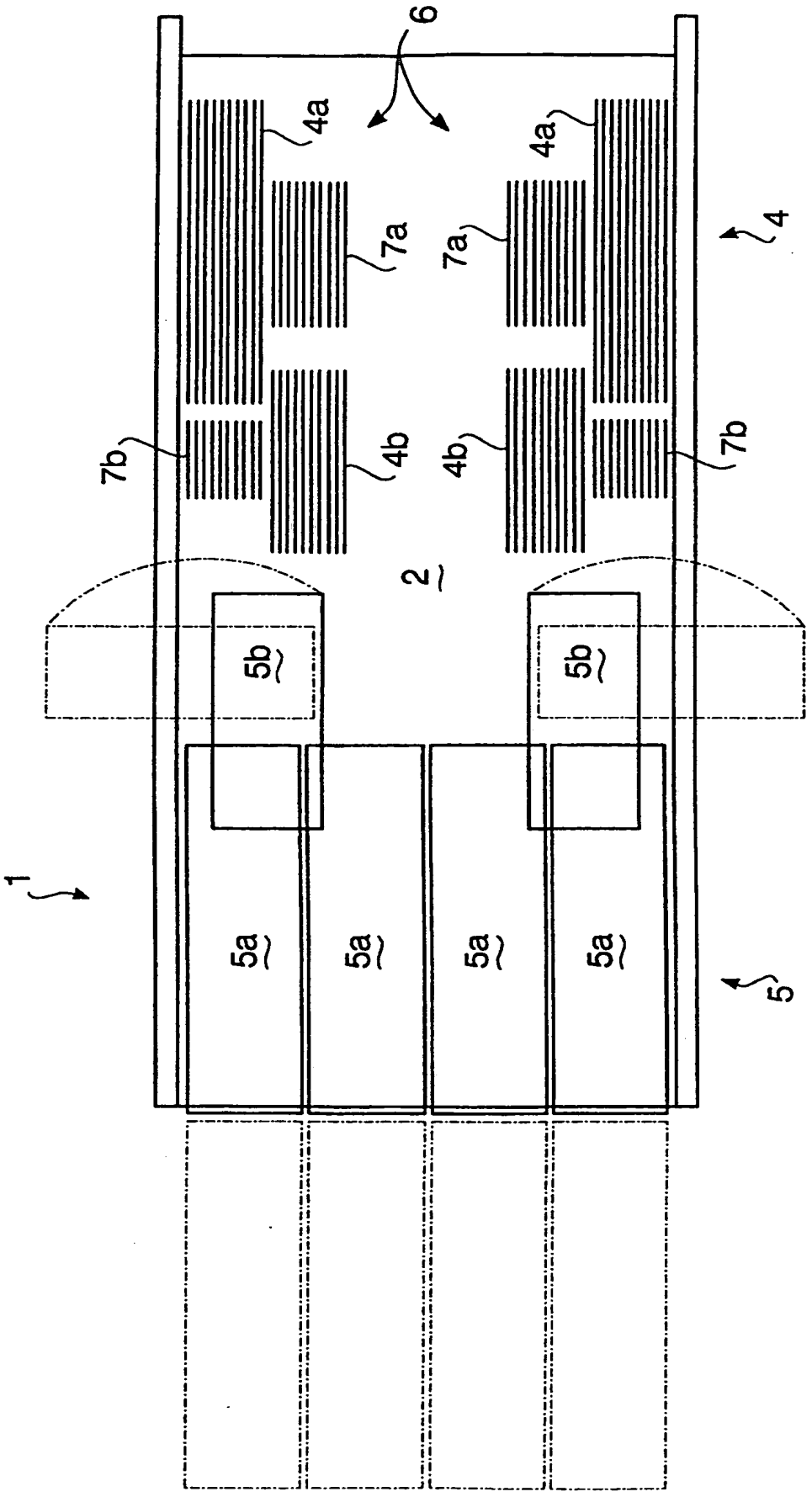

FIG. 5

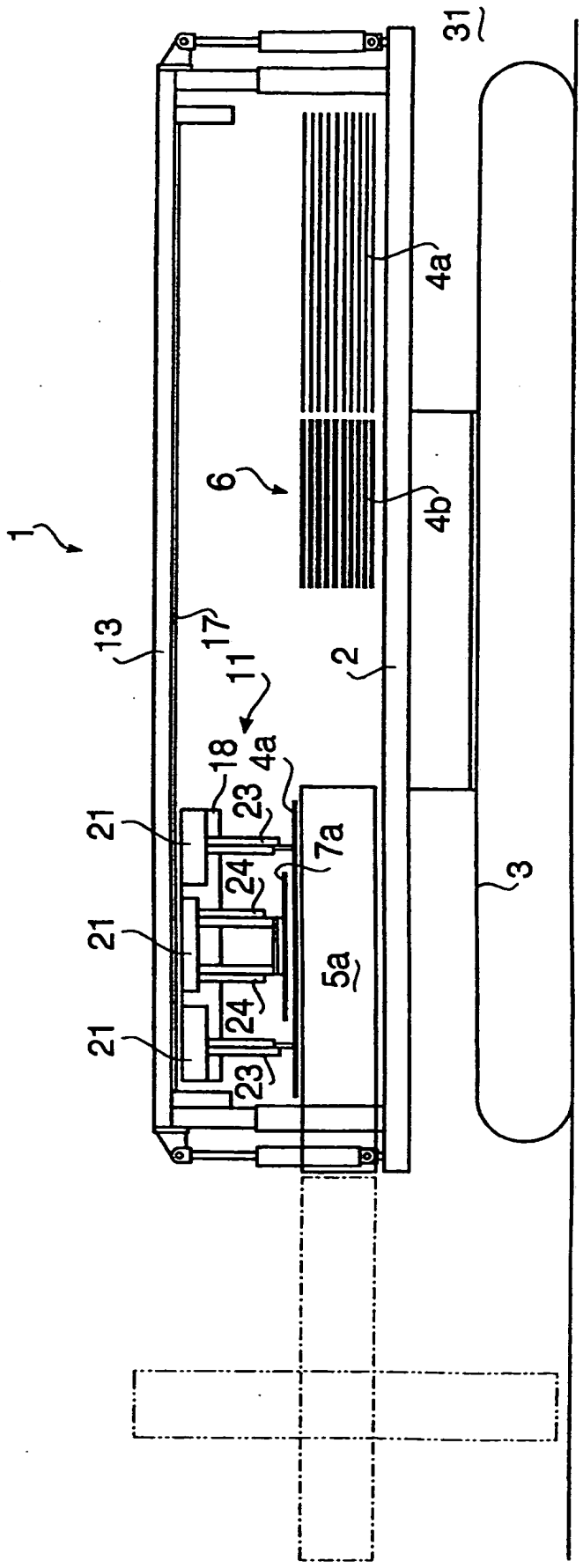

FIG. 6

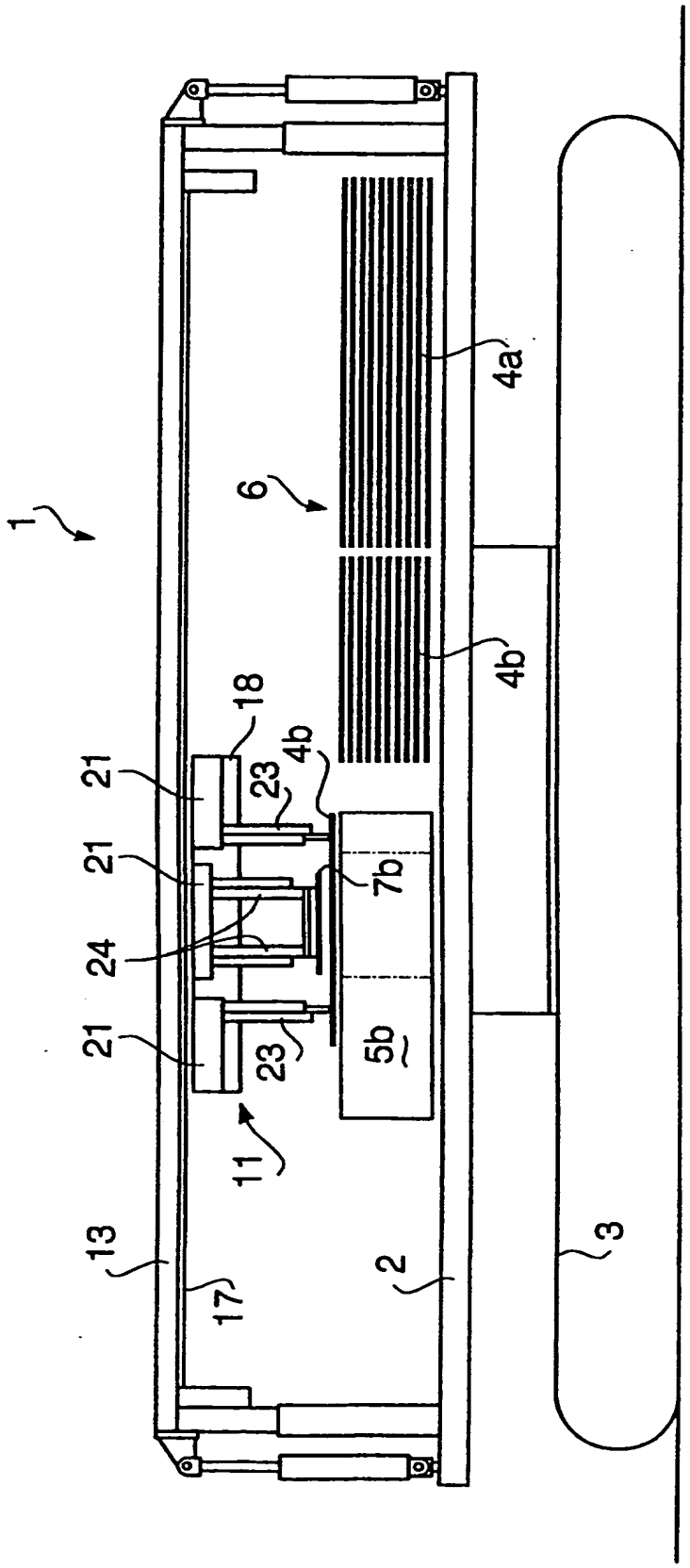

FIG. 7

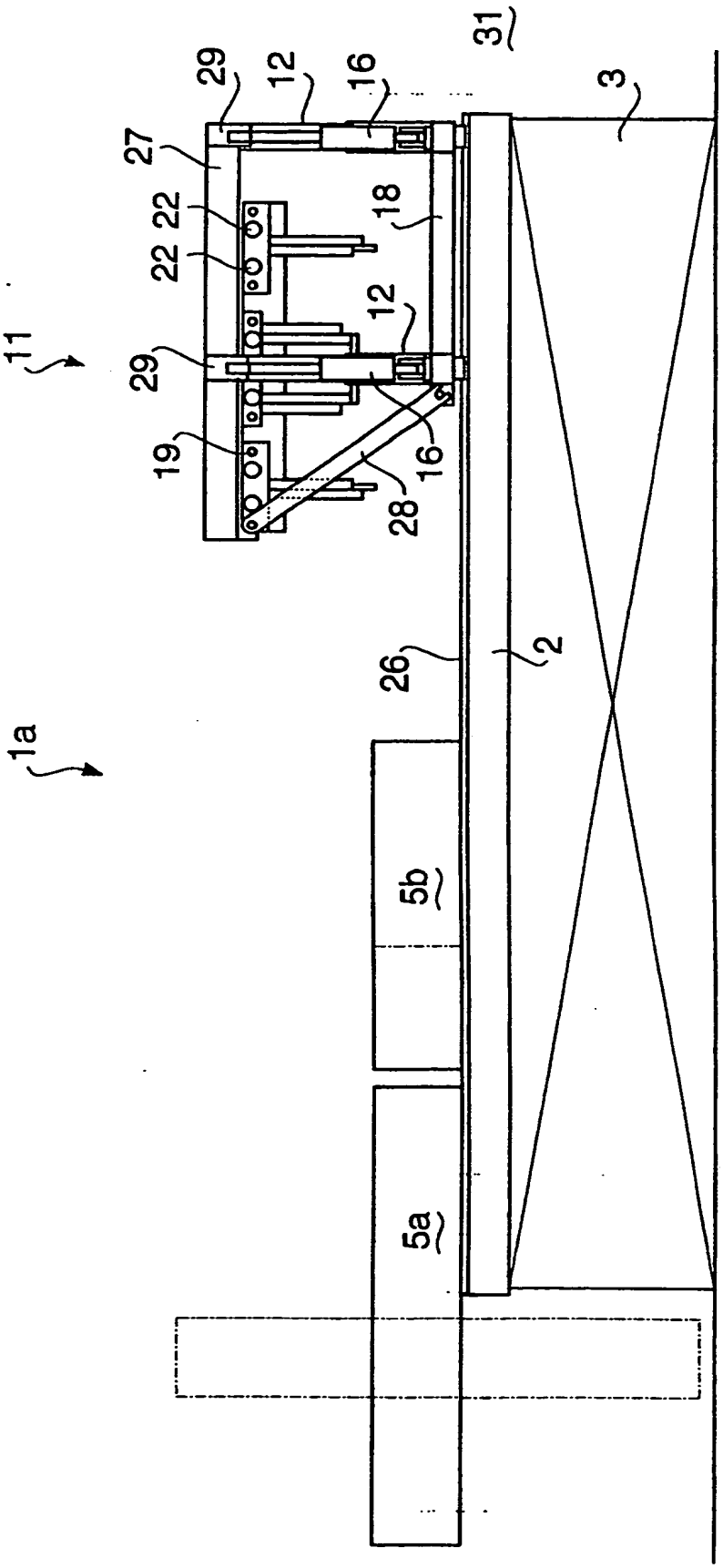

FIG. 8

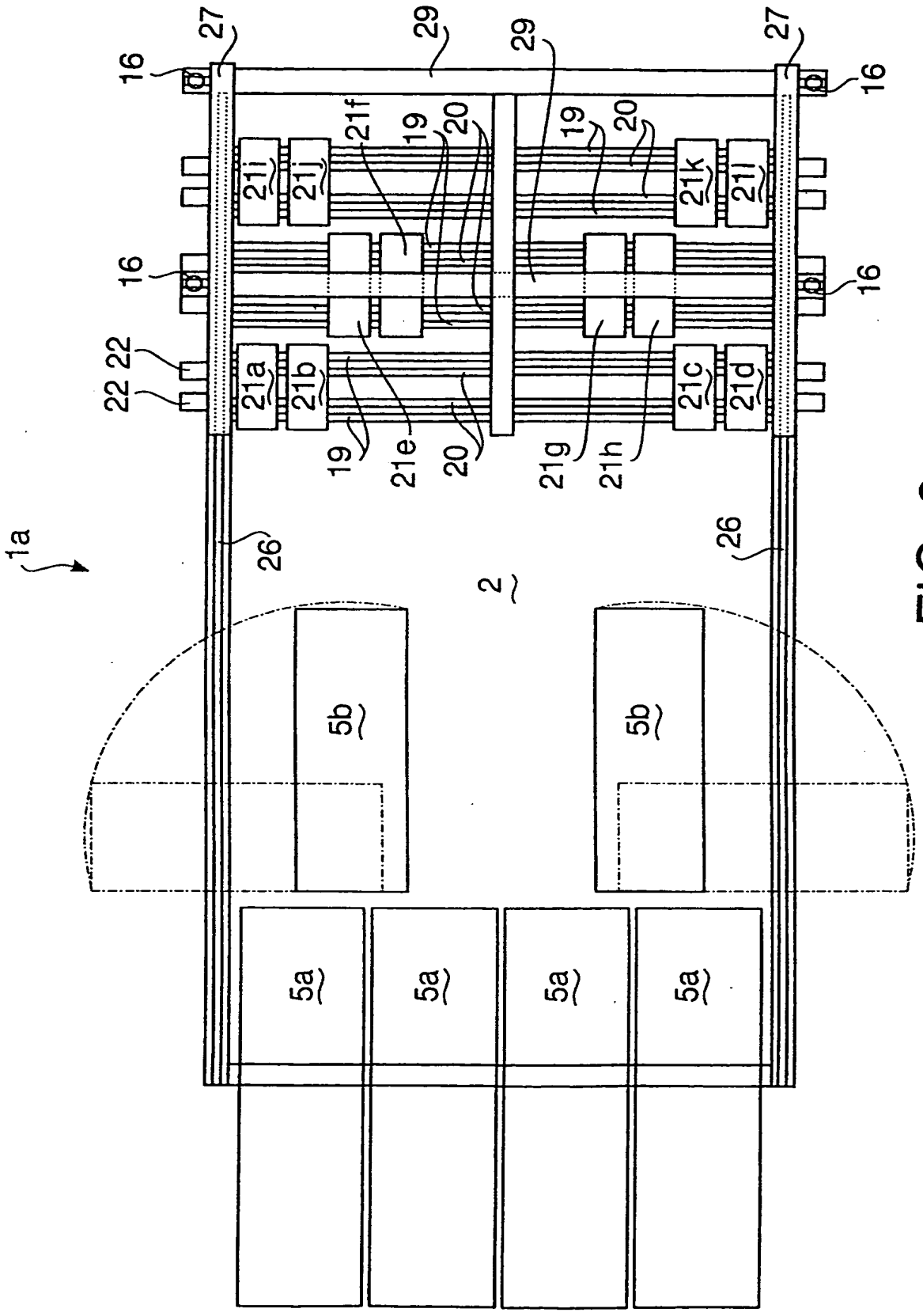
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FIG. 9

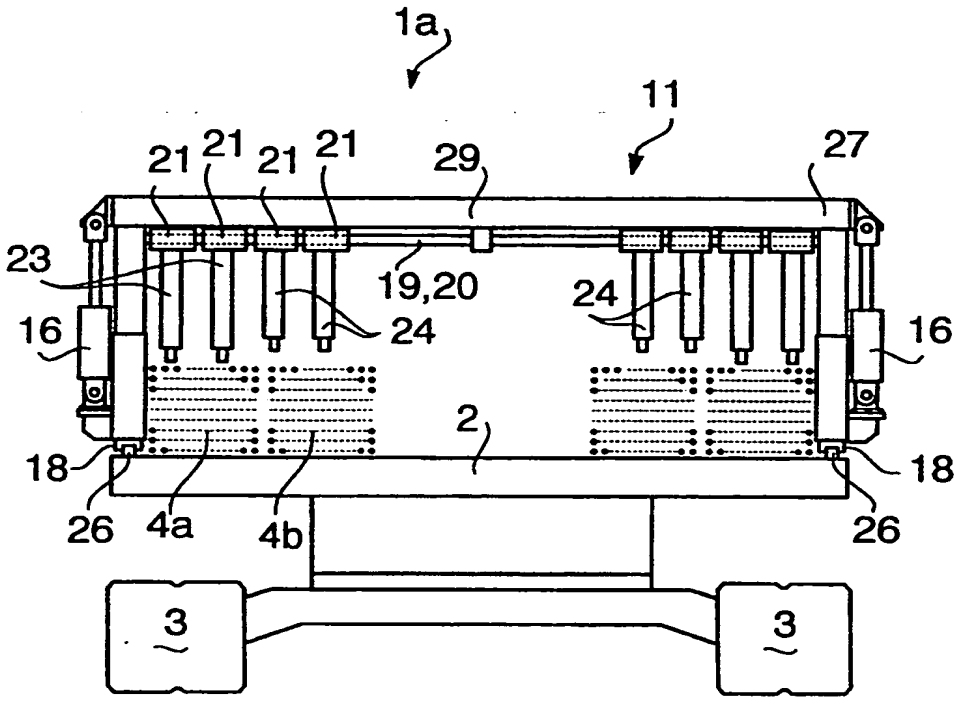
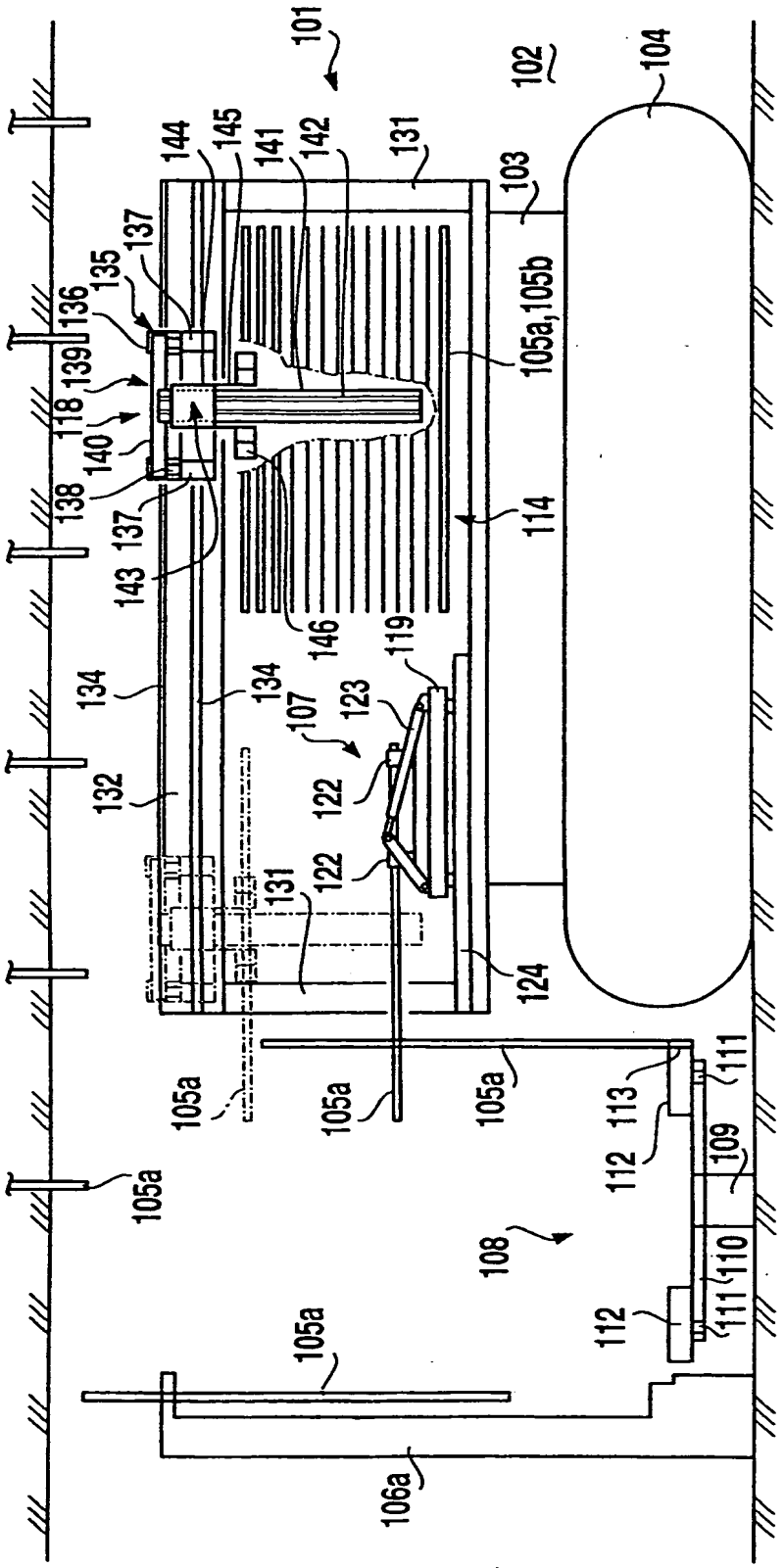


FIG. 10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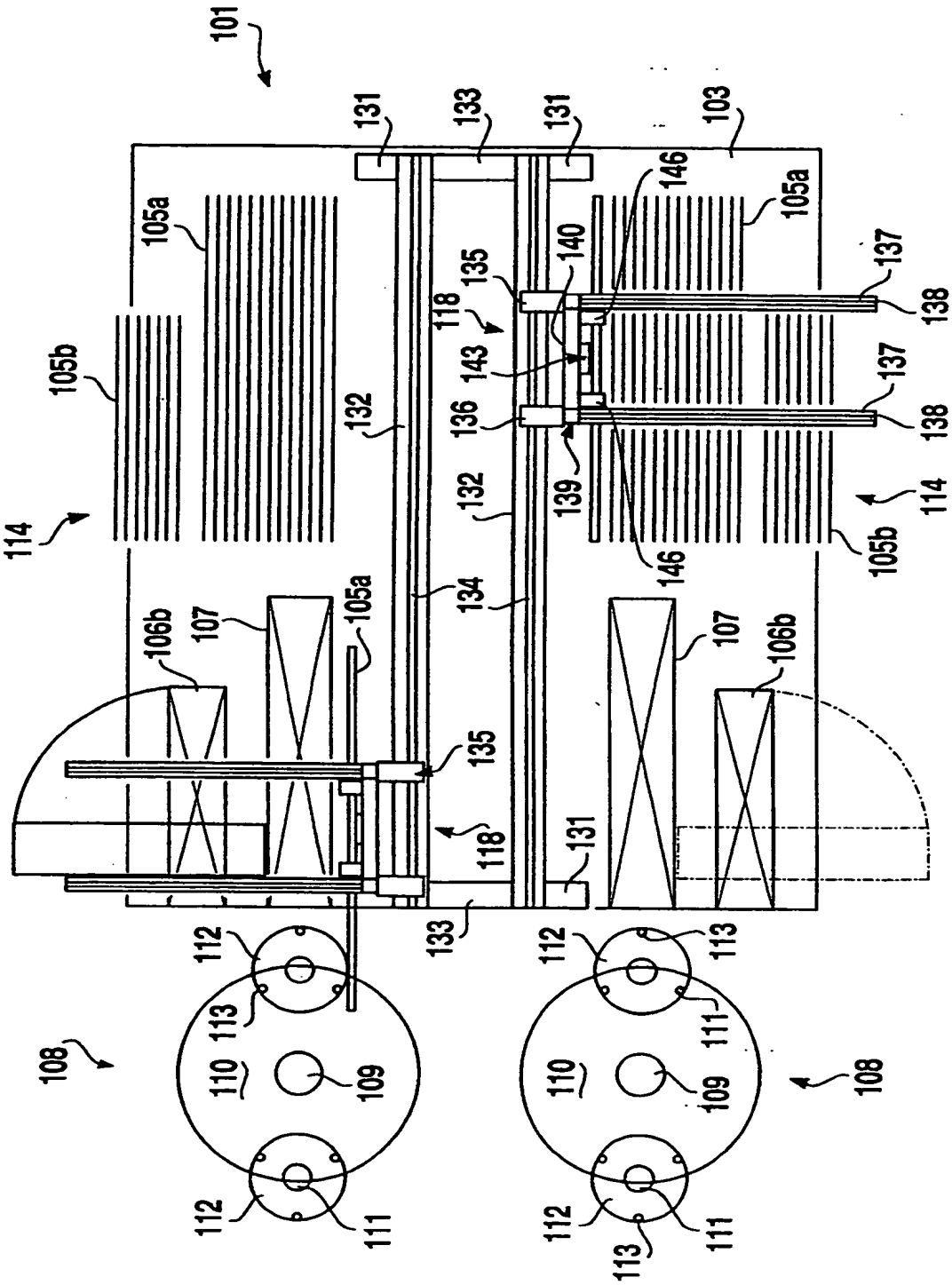
106a

FIG.11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105b
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132
139
114
146
105b
106b
107
105a
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106b
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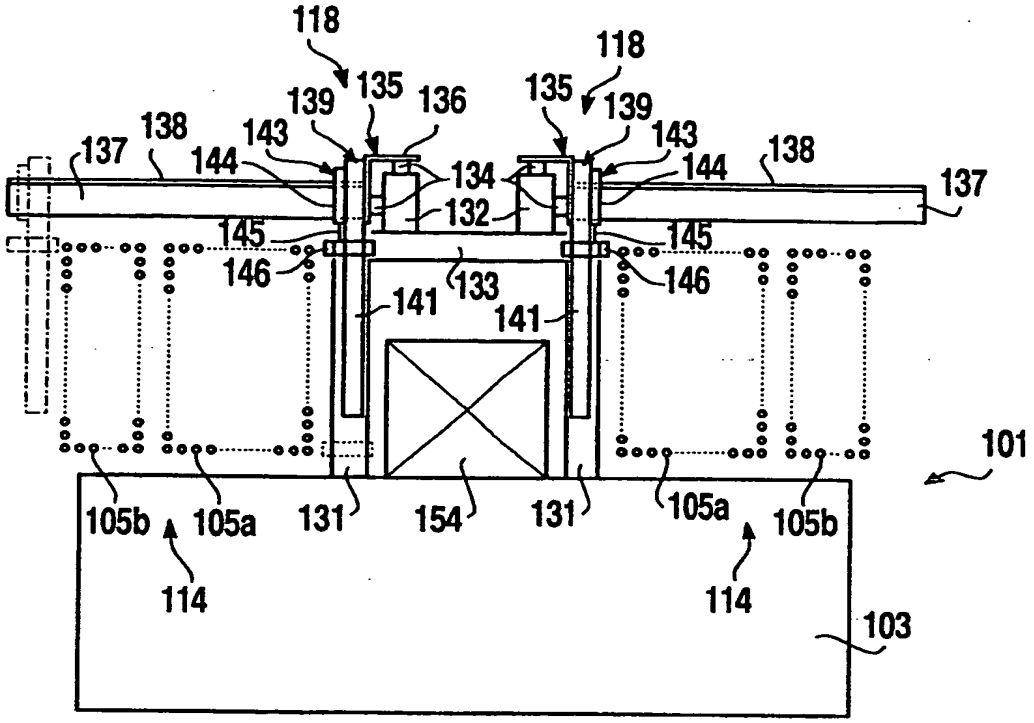
FIG.12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131
105a
105b
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114
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FIG.13

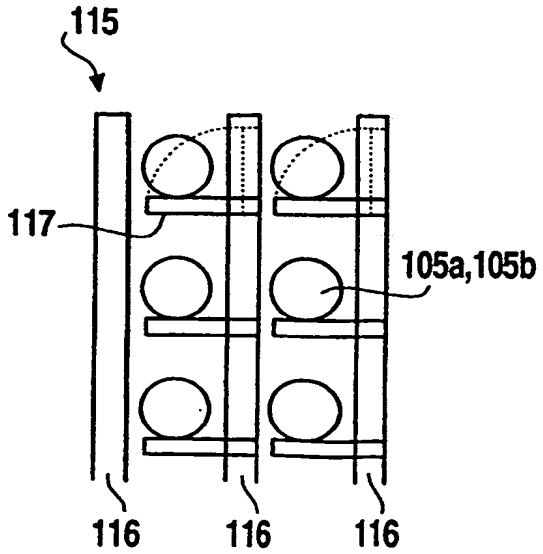
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FIG.14

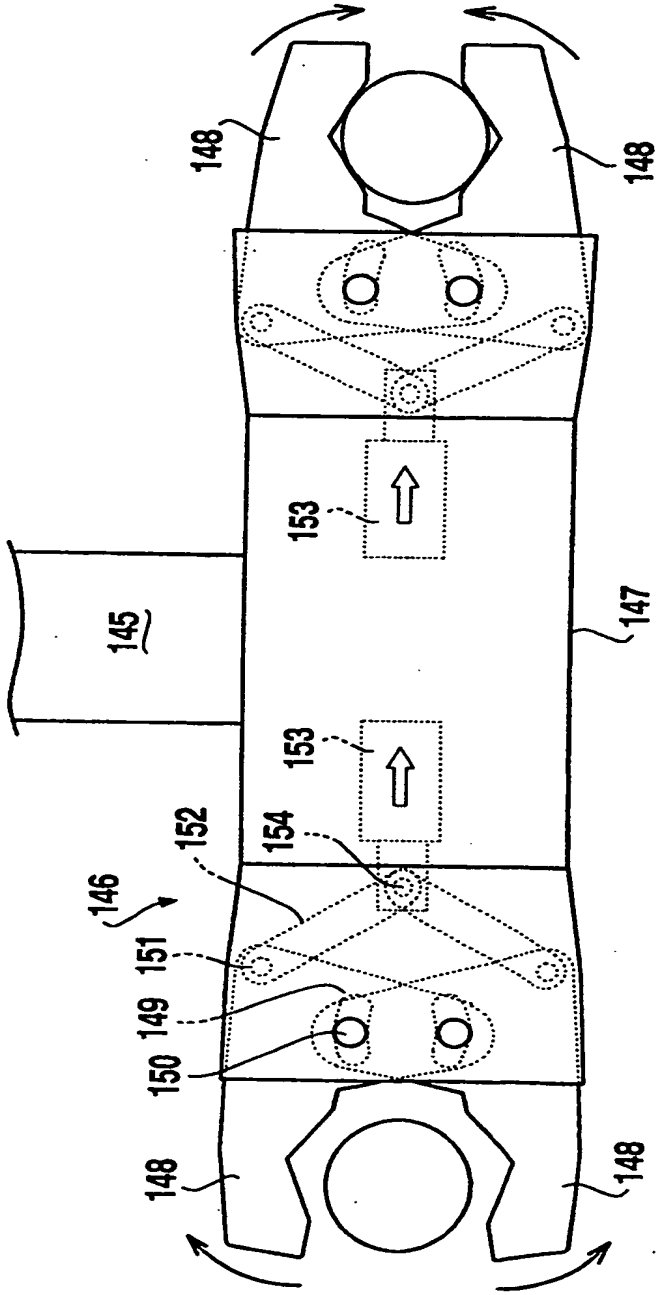


FIG.15

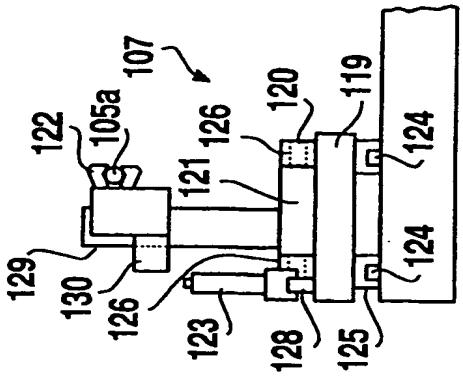


FIG.16(c)

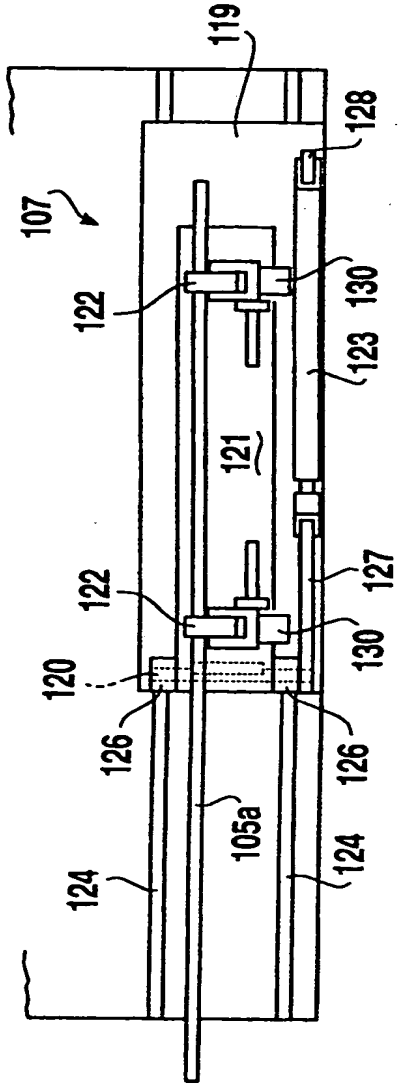


FIG.16(b)

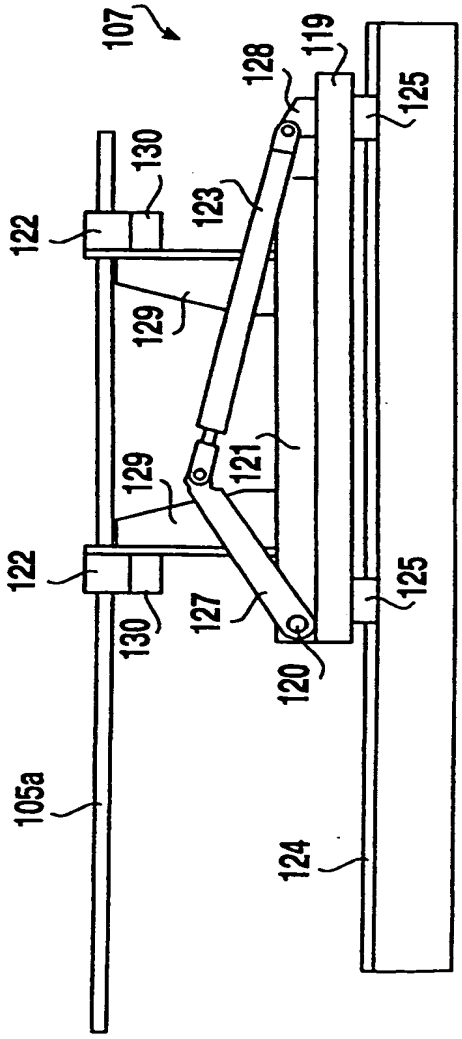
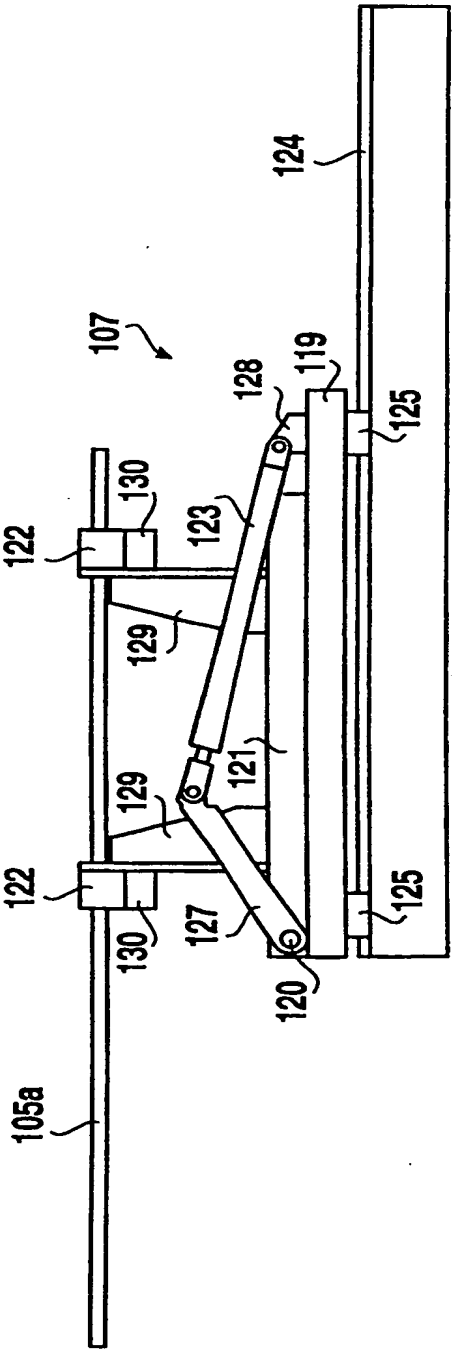


FIG.16(a)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105a

FIG.17

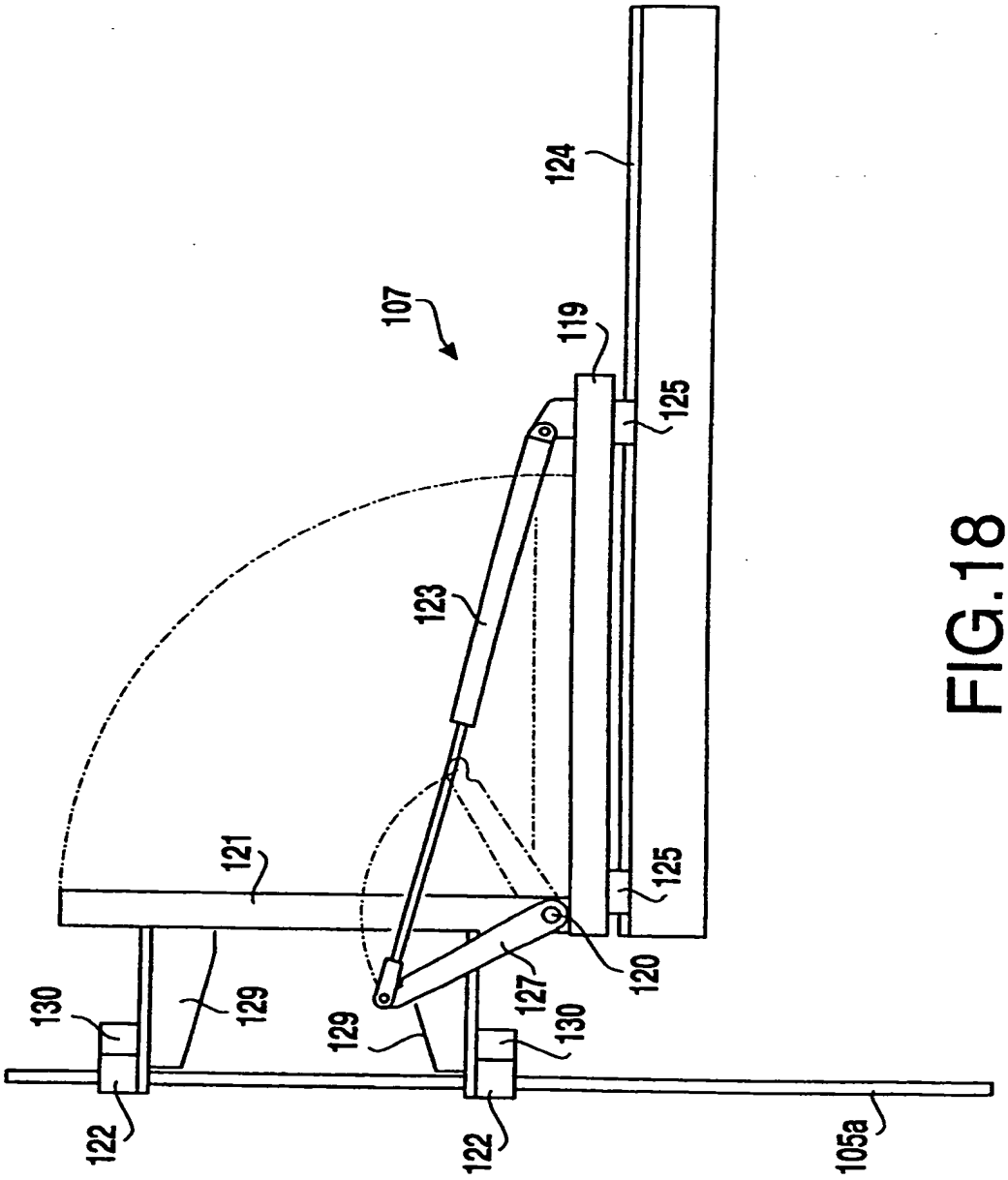
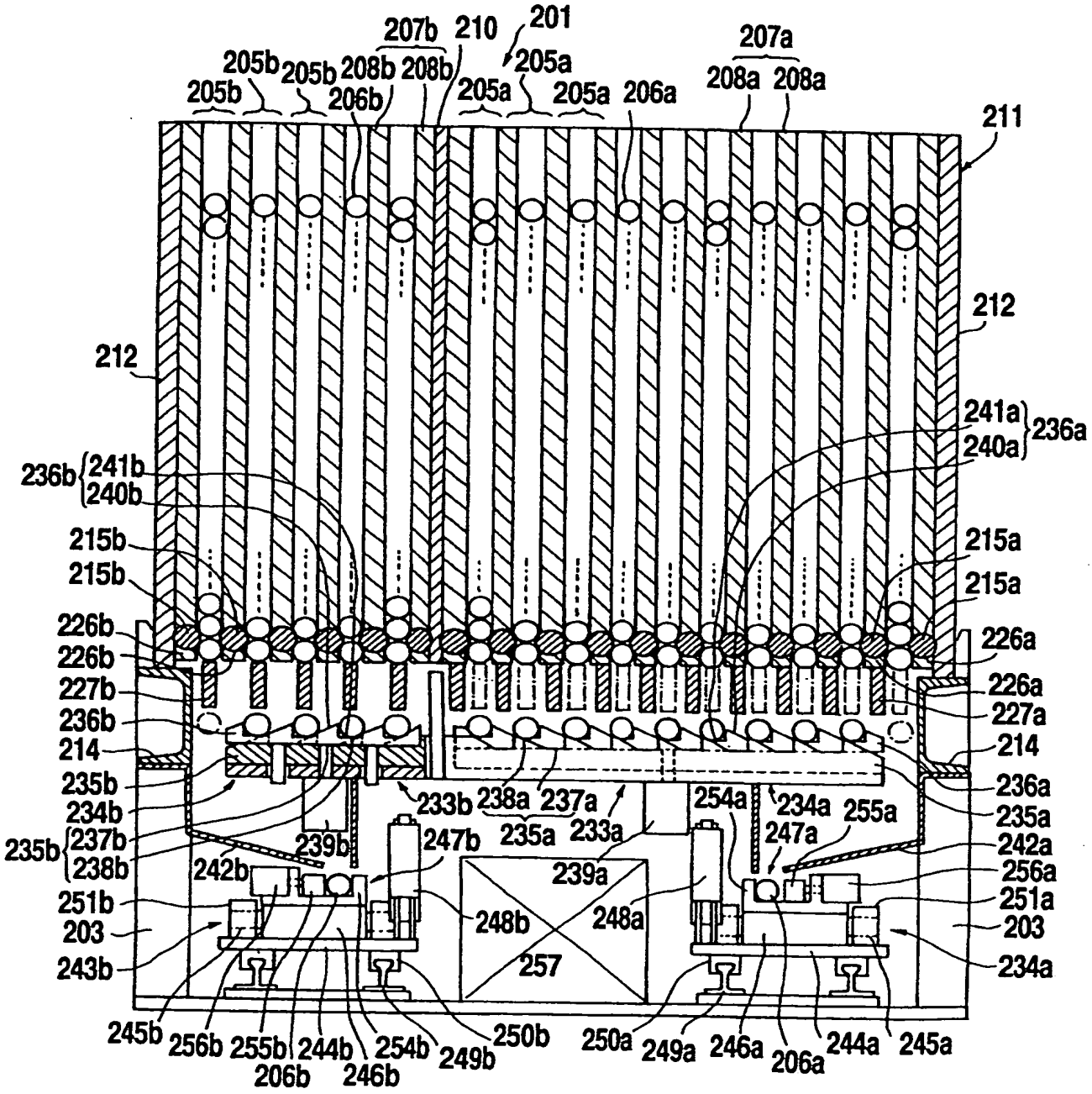


FIG.18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241a
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249b
206a

FIG.19

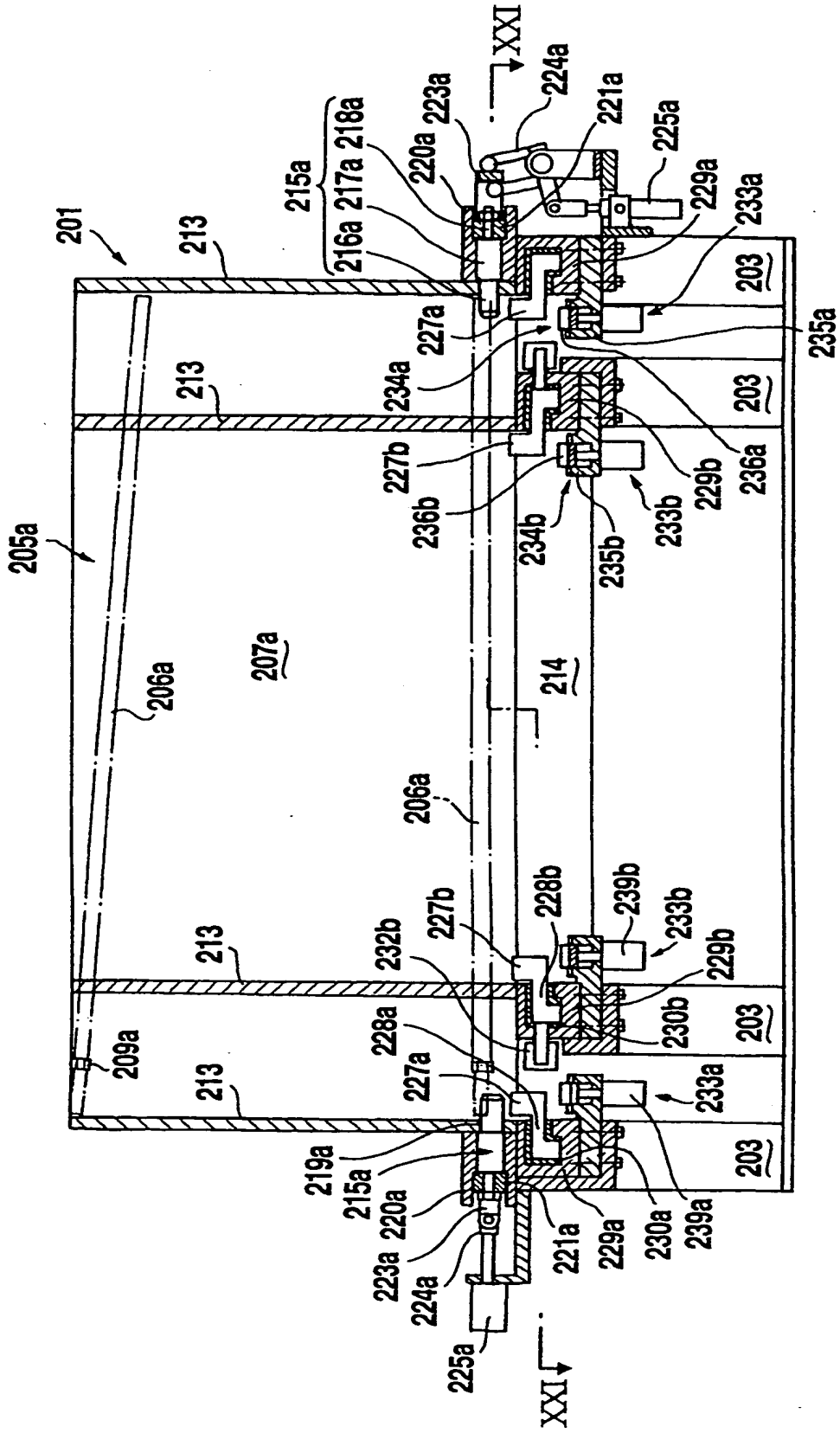
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FIG.20

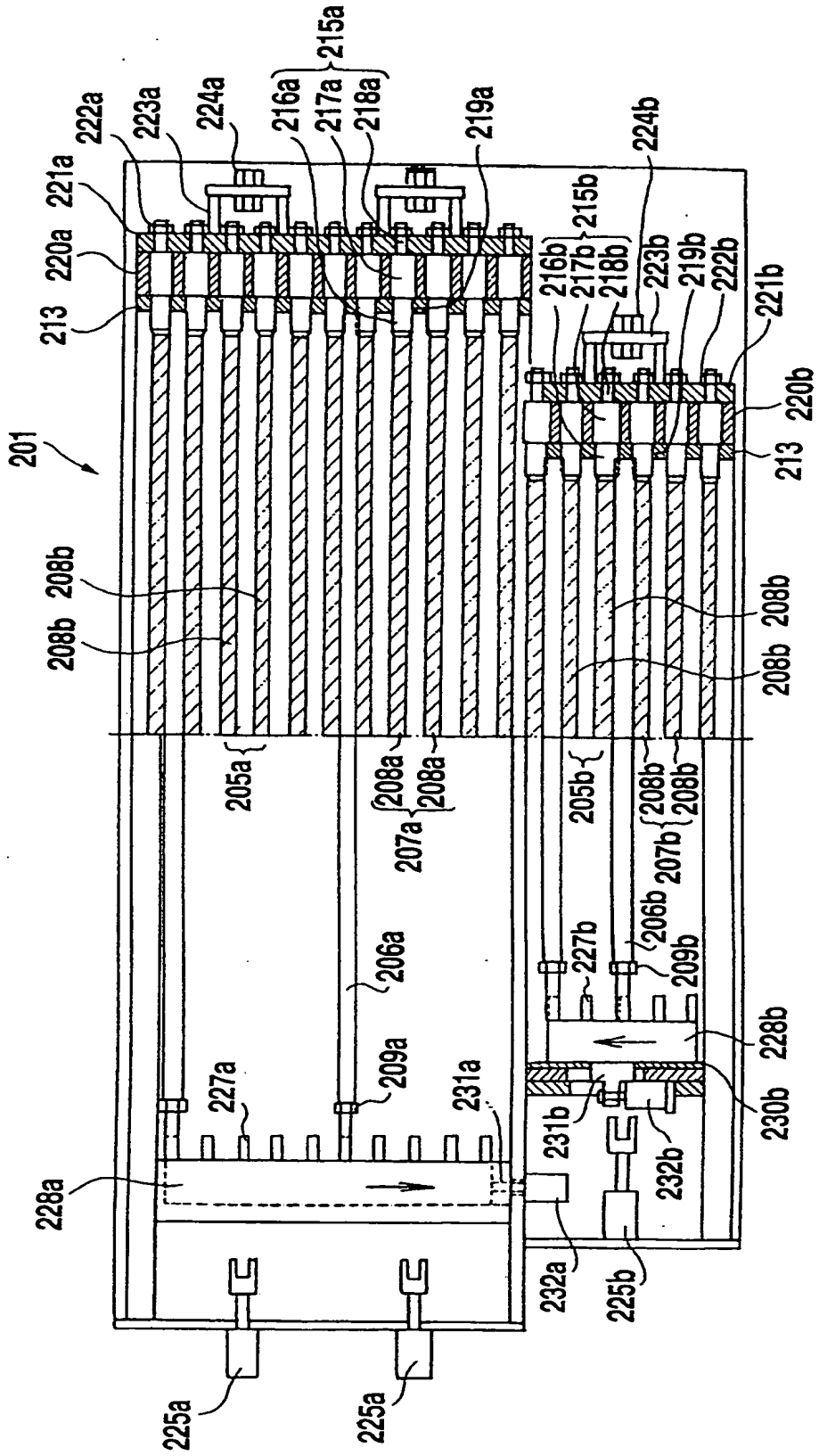
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FIG.21

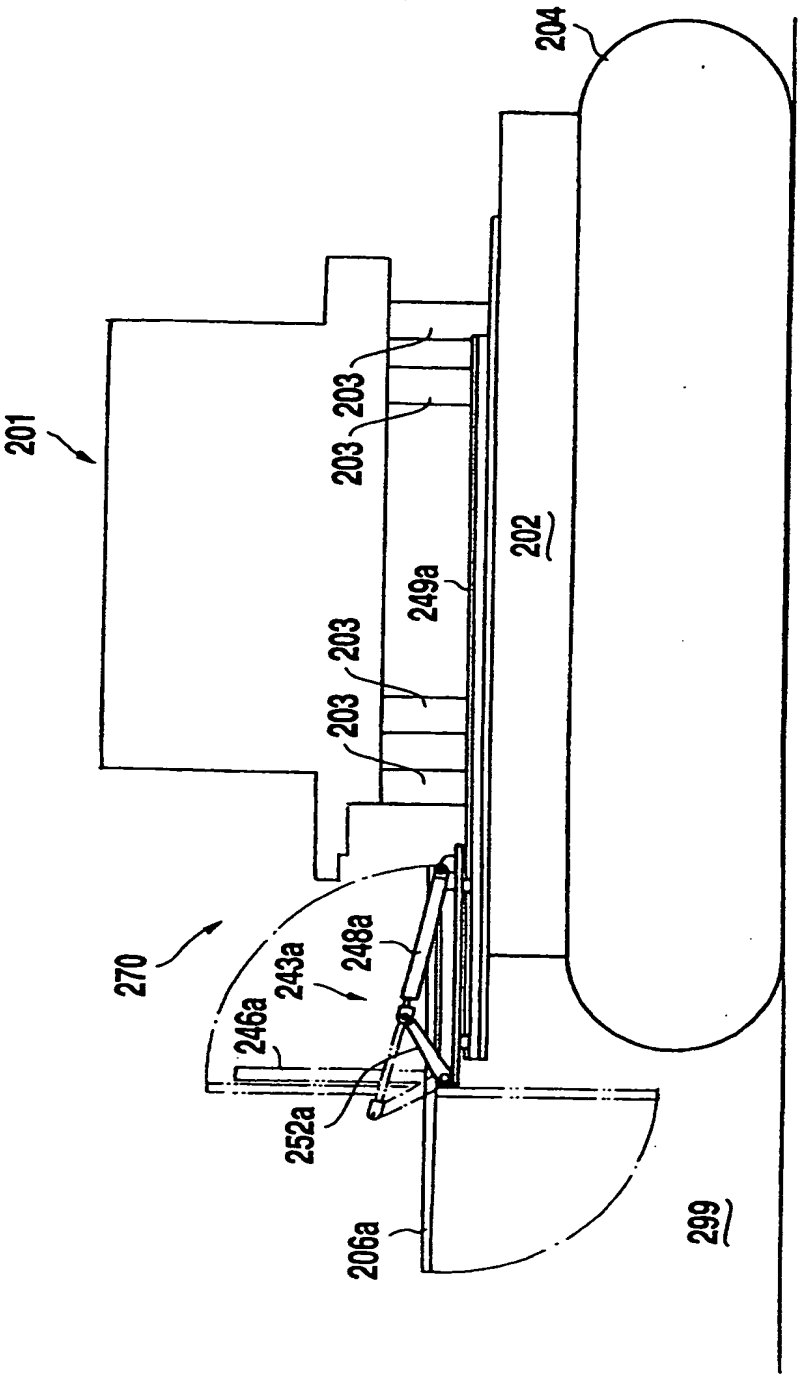
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FIG.22

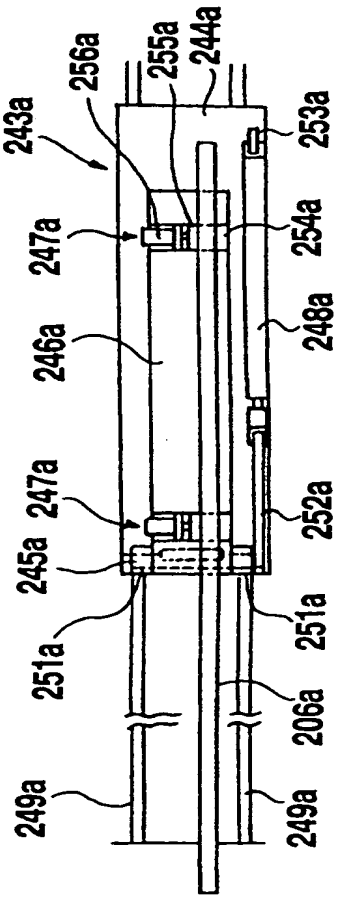

FIG.23(b)

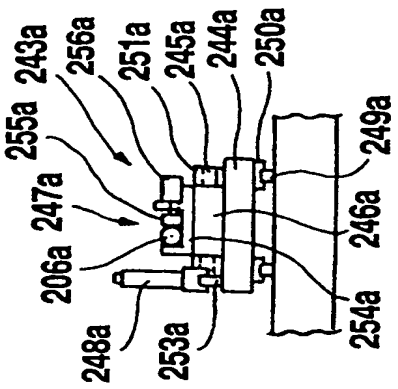

FIG.23(c)

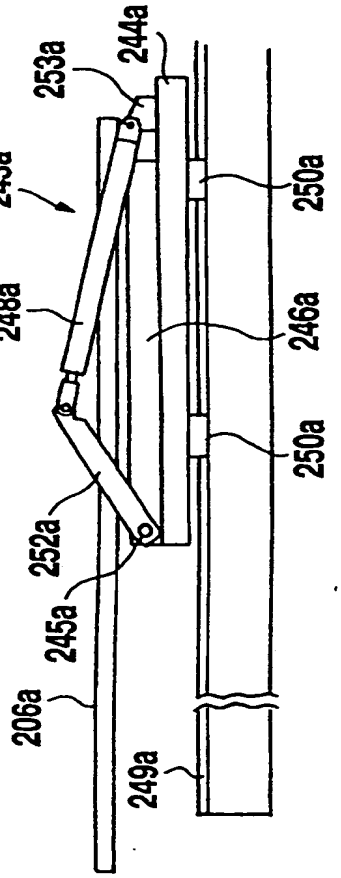

FIG.23(a)

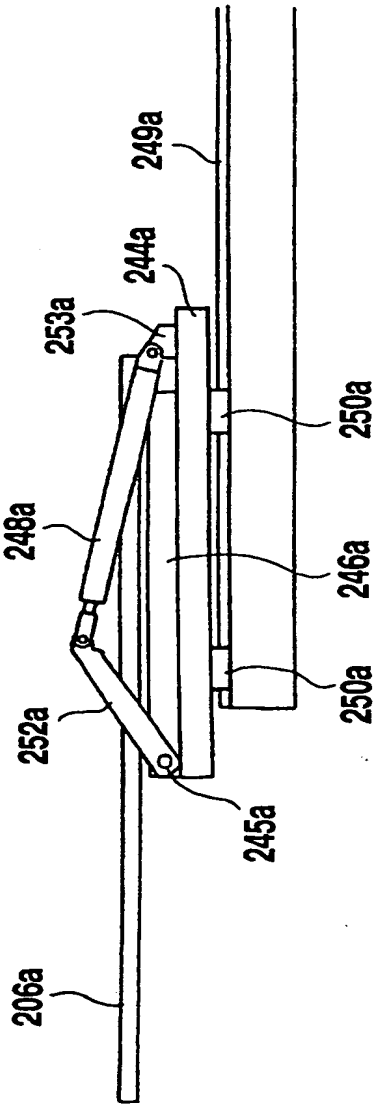

FIG.24

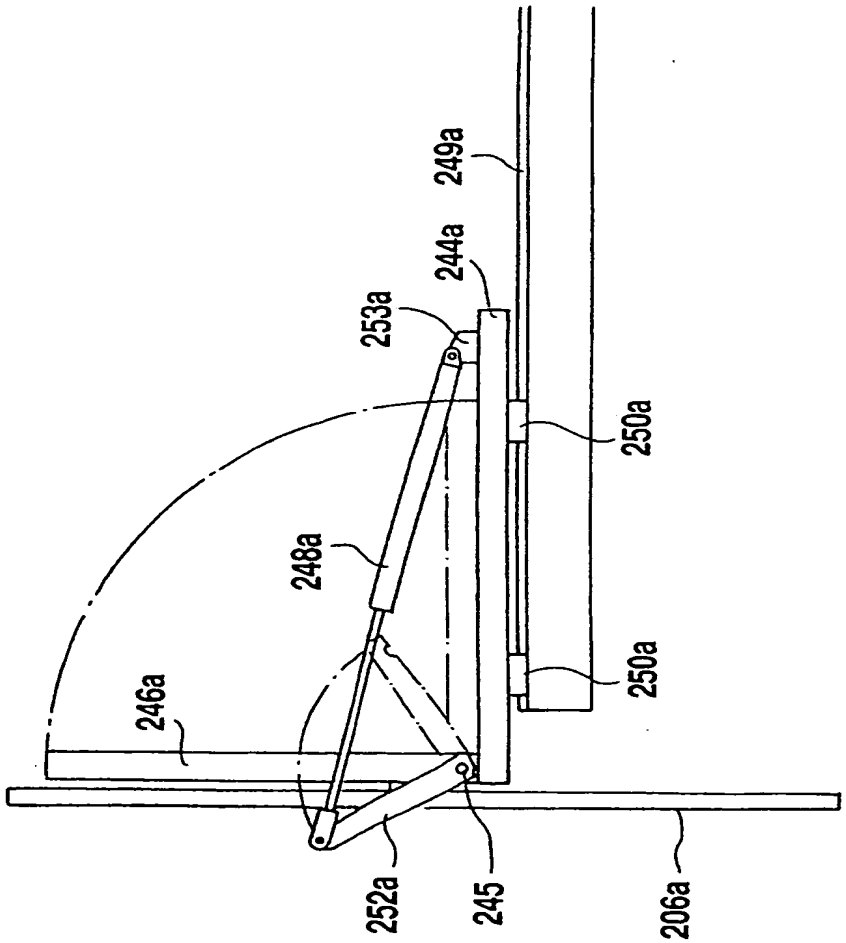

FIG.25

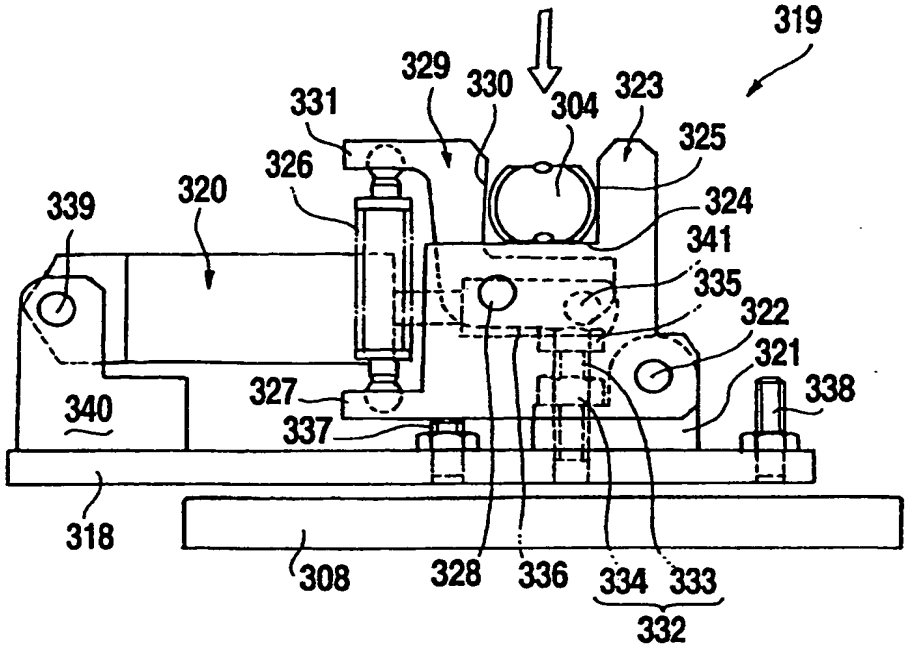
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FIG.26

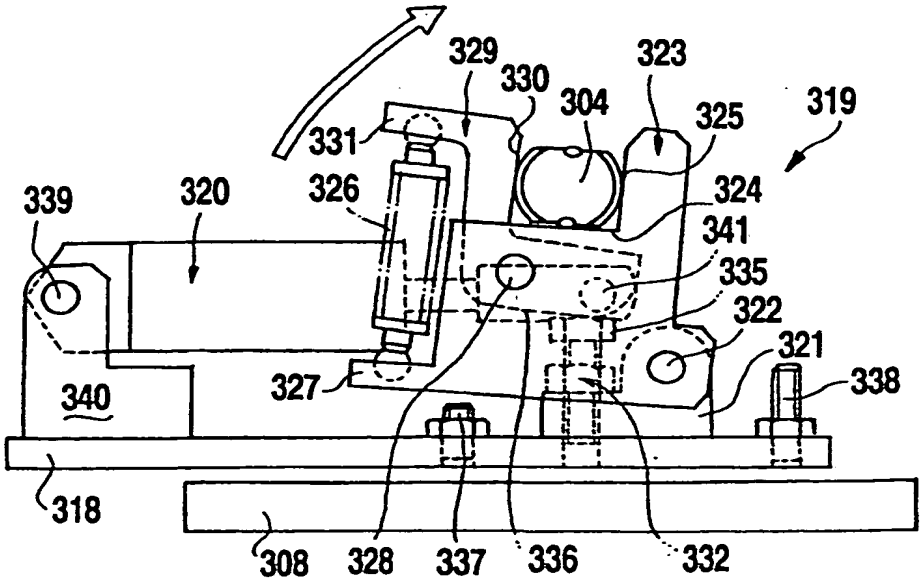
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FIG.27

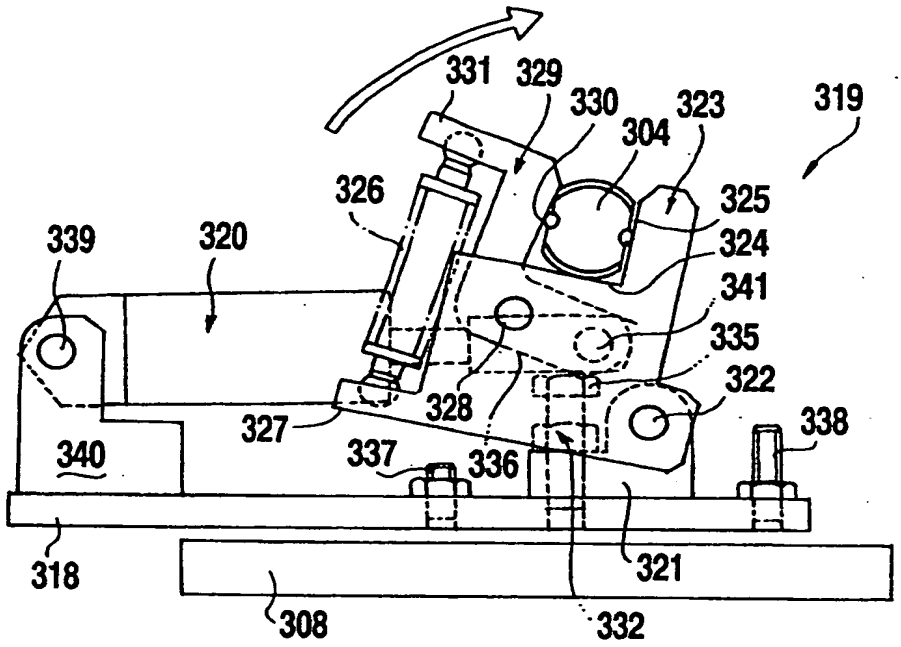
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FIG.28

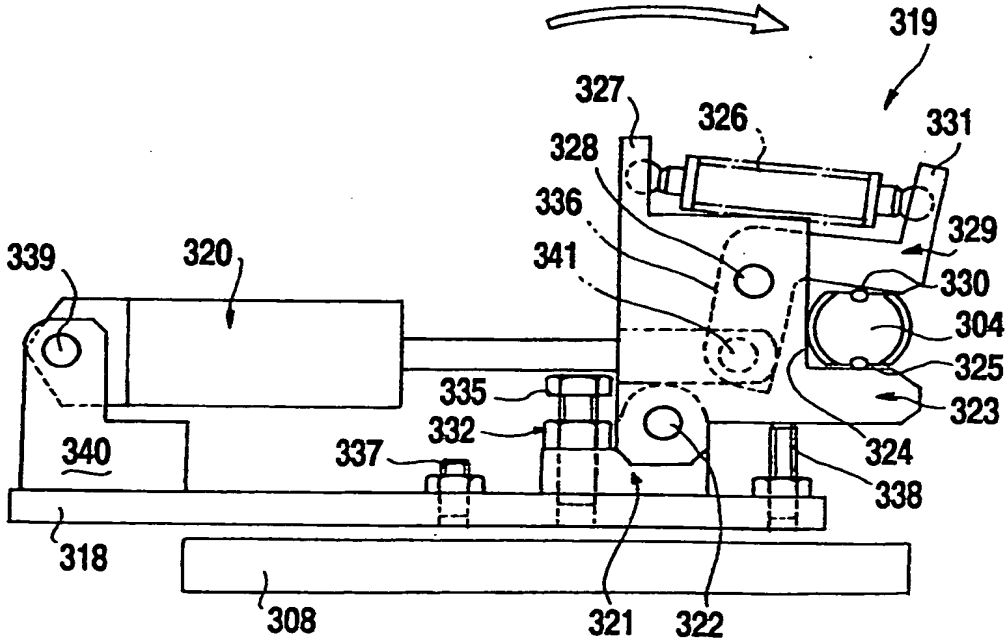
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FIG.29

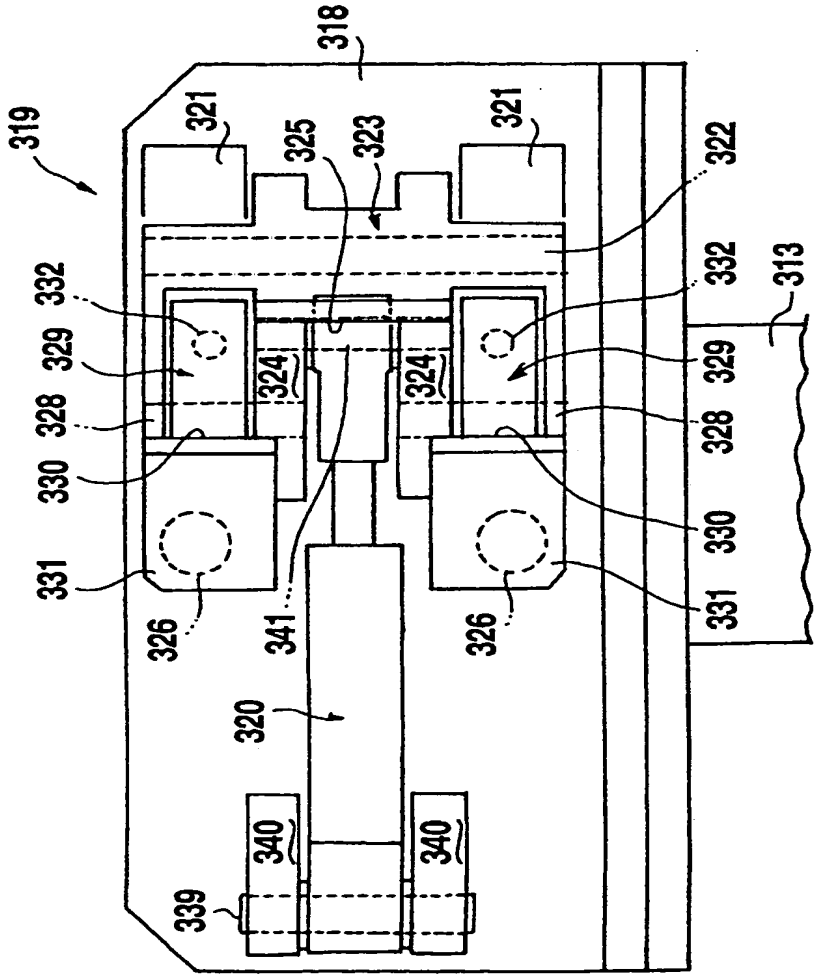
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FIG.30

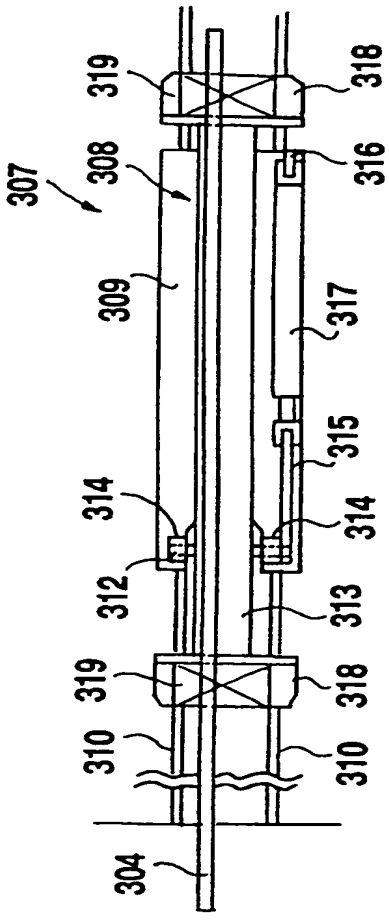

FIG.31(b)

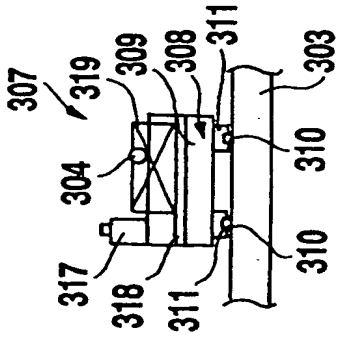

FIG.31(c)

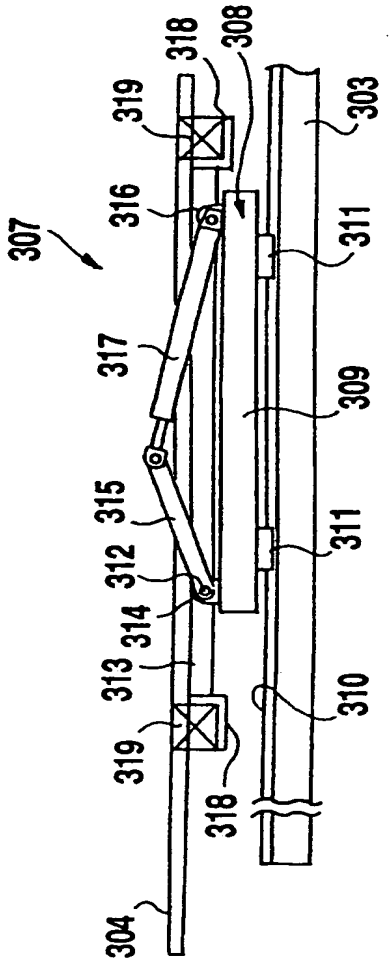

FIG.31(a)

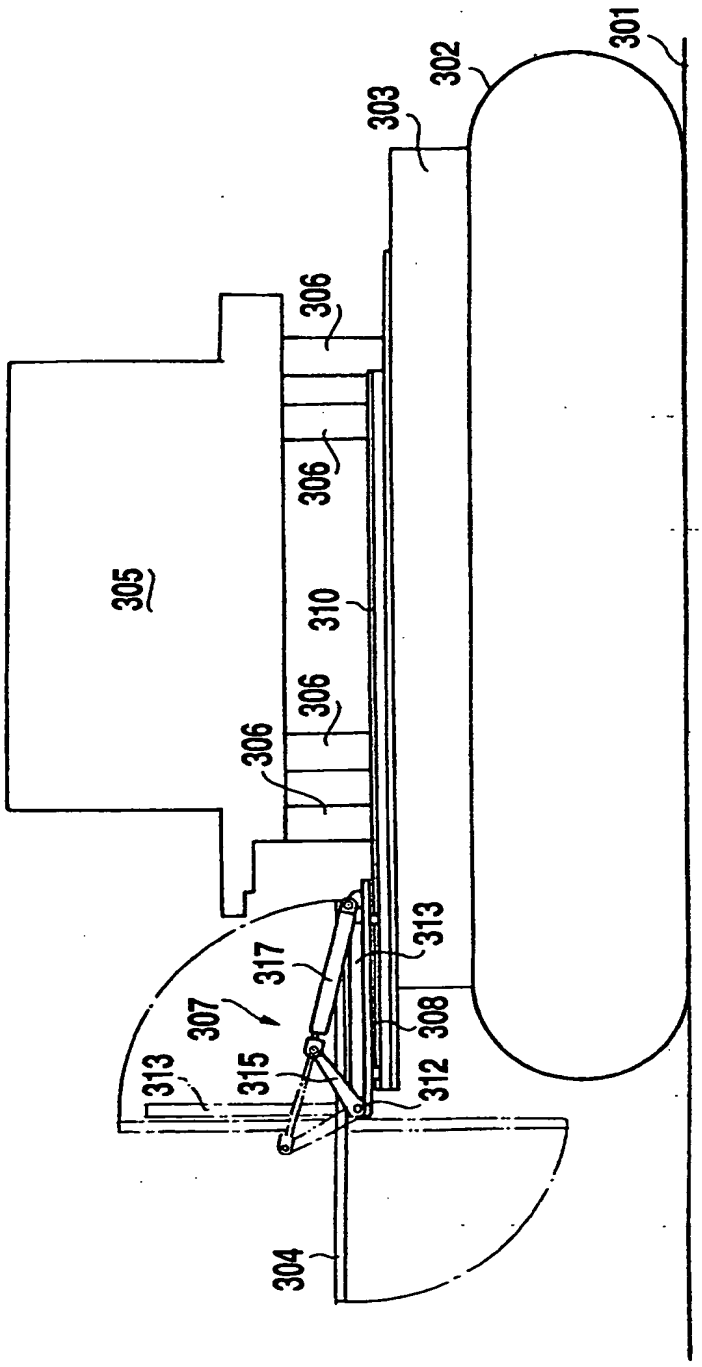
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FIG.32